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Southeast Florida Coral Reef Fishery-Independent Baseline Assessment

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Southeast Florida Coral Reef Fishery-Independent Baseline Assessment

2012-2014 Summary Report

National Oceanic and Atmospheric Administration
Coral Reef Conservation Program

Southeast Florida Coral Reef Fishery-Independent Baseline Assessment
2012-2014 Summary Report

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Cover photo: Kirk Kilfoyle

Executive Summary

Reef fishes are important biologic, ecologic, and economic resources of the marine ecosystem which must be managed for sustainability. Until recently, there was no long-term monitoring program in place to assess the condition of reef fish resources of the northern Florida Reef Tract (FRT) (northern Miami-Dade, Broward, Palm Beach, and Martin counties). An assessment/monitoring plan for the northern portion of the Florida reef tract was designed through a joint cooperative effort by scientists at the University of Miami, Rosenstiel School of Marine and Atmospheric Science (RSMAS), National Oceanic and Atmospheric Administration (NOAA)-Southeast Fisheries Science Center (SEFSC) and Nova Southeastern University Oceanographic Center (NSUOC). This report is a synoptic compilation of a three-year data collection from all partner agencies, and includes data from the 232, 324, and 308 sites or Primary Sampling Units (PSUs) sampled in 2012, 2013, and 2014, respectively. The majority of the field work was accomplished through funding provided to NSUOC by the NOAA Coral Reef Conservation Program (CRCP), with supplementary funding provided by FDEP-CRCP. Significant amounts of data were also collected by multiple Southeast Florida Coral Reef Initiative (SEFCRI) partner agencies that were able to dedicate their time and resources to the project. Field sampling for each year began in May and ran through October.

During the three-year study period, >560,000 individual fish of 289 species were recorded. Total mean density for all sites and strata combined for all three years was 170 fishes/SSU (Second-Stage Sample Unit = SSU or site, 177 m^2). For 2012, mean density was 151 fishes/SSU; in 2013 it was 168 fishes/SSU; and in 2014 it was 186 fishes/SSU. When low vs. high slope strata were compared, the high slope strata showed higher fish density. Multivariate analyses showed patterns in the reef fish communities associated with benthic habitats. Water depth was a primary determinant of fish distribution with differences in assemblages between shallow and deep sites. Also most of the surveys in the southern regions (Broward-Miami, Deerfield, and South Palm Beach) clustered tightly together indicating high similarity between communities in the deep habitats within these regions. Conversely, fish communities in North Palm Beach and Martin were much more variable and mostly separated in disparate areas of the plot. This suggests that the Martin and North Palm Beach fish communities are distinctly different from the southern regions.

The dataset, in its entirety, provides the opportunity for further mining to examine individual species and reef fish assemblage correlations with a host of abiotic and biotic variables. Thus, from both management and ecological-sciences perspectives, these data are a valuable resource. It is already clear there are significant differences in the geographic distribution of reef fishes at local and regional scales. There are interacting strata and latitudinal differences in total reef fish abundance, species distribution, sizes, and assemblage structure. The combination of data from all three years provides a complete regional baseline fishery-independent assessment.

Acknowledgements

The success of this project can be attributed to the cooperative partnerships forged between multiple key agencies, universities, and individuals who have a vested interest in maintaining the health and sustainability of the coral reef ecosystems of southeast Florida. We thank James Bohnsack and Jeremiah Blondeau (NOAA-SEFSC), and Natalia Zurcher (UM-RSMAS) for their essential support and guidance throughout this process. By sharing the expertise they have gained through many years of involvement with the parent RVC project during its evolution in the Florida Keys and Dry Tortugas, they have strengthened our preliminary monitoring efforts here along the northern reaches of the Florida Reef Tract. We thank both Kurtis Gregg (NMFS-Southeast Regional Office) and Dana Wusinich-Mendez (NOAA-CRCP) for their valuable assistance in helping to facilitate the fundamental partnerships vital to this project, acting as a sounding board for questions and new ideas, and for providing feedback during preparation of this document. Additional gratitude is extended to Kurtis for providing diving assistance in the field.

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List of Acronyms

ANOSIM	Analysis of Similarity
ANOVA	Analysis of Variance
CREIOS	Coral Reef Ecosystem Integrated Observing System
CRCP	Coral Reef Conservation Program
DERM	Department of Environmental Resource Management
FDEP	Florida Department of Environmental Protection
FDOU	Fishing Diving and Other Uses
FRRP	Florida Reef Resilience Program
FRT	Florida Coral Reef Tract
FWC	Florida Fish and Wildlife Conservation Commission
GIS	Geographic Information Systems
LAS	Local Action Strategy
LIDAR	Light Detection and Ranging
MDS	Multi-Dimensional Scaling
NFWF	National Fish and Wildlife Federation
NMFS	National Marine Fisheries Service
NRPMD	Natural Resources Planning and Management Division
NOAA	National Oceanic and Atmospheric Administration
NSUOC	Nova Southeastern University Oceanographic Center
PSU	Primary Sampling Unit
QA/QC	Quality assurance and quality control
RSMAS	University of Miami Rosenstiel School of Marine and Atmospheric Science
RVC	Reef Visual Census
SEFSC	Southeast Fisheries Science Center
SEFCRI	Southeast Florida Coral Reef Initiative
SE FL	Southeast Florida
SSU	Second-stage Sample unit
USCRTF	U.S. Coral Reef Task Force

1. INTRODUCTION

The ecosystem services of the Florida Reef Tract (FRT), including the diverse reef fish assemblage that it supports, have direct links to the health of both the state and local economies (Johns et al., 2001; Johns et al., 2004). Yet, it is widely believed and increasingly supported by multiple studies that many commercially and recreationally important fishes have been over-harvested and stocks are currently being exploited at an unsustainable rate throughout the region (Ferro et al., 2005; Johnson et al., 2007; Ault and Franklin, 2011; Gregg, 2013a). Furthermore, a wide array of other acute and chronic anthropogenic impacts are applying increasing levels of additional stress to the entire reef system, e.g., coastal construction projects, sedimentation, ship groundings and anchor damage, water pollution and other water quality issues (Banks et al. 2008; Jordan et al., 2009; Behringer et al., 2011; Walker et al., 2012; Gregg, 2013b). These impacts are closely linked to the growing human population that resides in the highly developed coastal region of southeast Florida. Because reef fishes are an important biologic, ecologic, and economic resource of the marine ecosystem, reef fish population trends and the associated potential driving forces need to be examined closely in order to understand and effectively manage these resources sustainably. In 1979, fishery-independent monitoring of reef fish populations began in the Florida Keys (the southern portion of the FRT from Dry Tortugas to Biscayne National Park). However, until recently there was no comparable fishery-independent data collection in place to assess the status of reef fish resources associated with the northern portion of the FRT (northern Miami-Dade, Broward, Palm Beach, and Martin counties).

Under the guidance of the U.S. Coral Reef Task Force (USCRTF), the Florida Department of Environmental Protection (FDEP) and the Florida Fish and Wildlife Conservation Commission (FWC) coordinated the formation of a team of marine resource professionals (local, state, regional, and federal), scientists, non-governmental organization representatives, and other coral reef stakeholders. This group, known as the Southeast Florida Coral Reef Initiative (SEFCRI) Team, gathers to develop local action strategies targeting coral ecosystems in Miami-Dade, Broward, Palm Beach and Martin counties.

The SEFCRI Team identified the need for the development of a fishery-independent monitoring program for southeast Florida’s coral reefs in 2004. This management need was again identified by stakeholders, managers, and scientists in 2008 during the Florida Reef Resilience Program (FRRP) Workshop and most recently by managers and scientists at the National Oceanic and Atmospheric Administration (NOAA) Atlantic/Caribbean Coral Reef Ecosystem Integrated Observing System (CREIOS) Workshop, and at Florida’s Strategic Management Priorities Workshop. The need for fishery-independent information was confirmed in 2008 as contractors began gathering fishery-dependent and independent data for SEFCRI Local Action Strategy (LAS) Fishing, Diving, and Other Uses (FDOU) Project 18 & 20A: *Fisheries Resource Status and Management Alternatives for the Southeast Florida Region*. The contractors found several “snapshot” fishery-independent datasets in two of the four counties within the four-county region. With one exception (Ferro et al., 2005), these datasets mainly focused on artificial reef fish populations, and were only collected for one to two years. Preliminary results from Project 18 & 20A indicated that spatially and temporally explicit fishery-independent assessment on southeast Florida coral reefs was lacking and existing “snapshot” data could not be used to determine southeast Florida coral reef fish status and trends. Thus, the development of a fishery-independent assessment program for the region was recommended (Ault et al., 2012).

In 2011, Nova Southeastern University Oceanographic Center (NSUOC) received funding through the National Fish and Wildlife Federation (NFWF) to develop a training program aimed at building the capacity to conduct a large-scale assessment of reef fish populations in southeast Florida. The assessment project was designed through a joint cooperative effort by scientists at the University of Miami Rosenstiel School of Marine and Atmospheric Science (RSMAS) and NOAA-Southeast Fisheries Science Center (NOAA-SEFSC) with the goal to effectively build on the success of the fishery-independent monitoring program implemented in the Florida Keys and apply it to the northern portion of the FRT. A robust statistical design and sampling plan for an initial region-wide survey was developed with additional assistance from, and archival data being provided by, scientists at NSUOC (Ault et al., 2012) (FDEP-CRCP Project 3A) (http://www.dep.state.fl.us/coastal/programs/coral/reports/DEP_CRCP_3a_Report.pdf). The data acquired in the assessment has enabled resource managers to examine the Florida Coral Reef Tract on a holistic scale and to more accurately assess the status of the reef fish resources, as well as to conduct system-wide stock assessments.

While the majority of the field work for this project was accomplished through funding granted to NSUOC, a significant portion of the data were collected by multiple partner agencies that were able to dedicate their time and resources to the project: NOAA-SEFSC, NOAA-Fisheries Southeast Region, Habitat Conservation Division (HCD), FDEP-CRCP, FDEP-Southeast District, Miami-Dade County (DERM), Broward County (NRPMD), and the FWC Tequesta laboratory. Funding to collect data at 200 sites throughout the southeast Florida region was awarded by FDEP-CRCP to NSUOC on July 1, 2012. Field sampling began that same month and continued through October of 2012. Funding for the second year of sampling was awarded by the NOAA Coral Reef Conservation Program (CRCP) to NSUOC through the National Coral Reef Institute Cooperative Agreement on June 18, 2013, and a supplemental grant from FDEP-CRCP was awarded to NSUOC on July 15, 2013. Field sampling began in May and ran through October of 2013. Funding for the third year of sampling was awarded by the NOAA-CRCP to NSUOC through the Cooperative Institute for Marine and Atmospheric Studies (CIMAS) at RSMAS on July 1, 2014, and a supplemental grant from FDEP-CRCP was awarded to NSUOC on July 1, 2014. Field sampling for the third year of the assessment began in May and ran through October 2014. This report is a compilation of the three-year data collection from all partner agencies, and includes data from 232, 324, and 308 sites sampled in 2012, 2013 and 2014, respectively. The combination of data from all three years provides a complete regional baseline fishery-independent assessment.

2. PROJECT GOALS AND OBJECTIVES

The main goal of this project is implementation of a cooperative and statistically robust, habitat-based, tiered fishery-independent sampling protocol designed to meet two main objectives: 1) to determine the current status of southeast Florida reef fish populations which will enable detection of changes in these populations in response to future management strategies, and 2) to provide a seamless integration with the existing Reef Visual Census (RVC) program data, which will allow for the entire FRT to be evaluated in a holistic manner. In addition, this project is intended to continue fostering beneficial partnerships among NSUOC, NOAA National Marine Fisheries Service (NMFS), NOAA-CRCP, FDEP-CRCP, FWC, and other Keys RVC and local southeast FL partner agencies and organizations.

Implementation included: project planning, in water field work/data collection, data entry, data quality assurance and quality control (QA/QC), data analysis, report writing, coordination with SE FL partners, Geographic Information Systems (GIS) analyses, and determination of sites for each subsequent survey season.

3. METHODOLOGY

3.1. Study Area and Design

The study area included all previously mapped marine benthic hardbottom habitats shallower than 33 m from Government Cut in Miami-Dade County to the northern border of Martin County (Figure 1). The survey area for the annual FL Keys RVC survey spans south from Biscayne Bay National Park through the Florida Keys. The sampling design for the northern portion of the FRT was created with local stakeholder input in a separate FDEP-CRCP project by Ault et al. (2012). The plan adapted the stratified, random statistical sampling design developed and implemented for the Florida Keys reef fish monitoring plan (Smith et al., 2011).

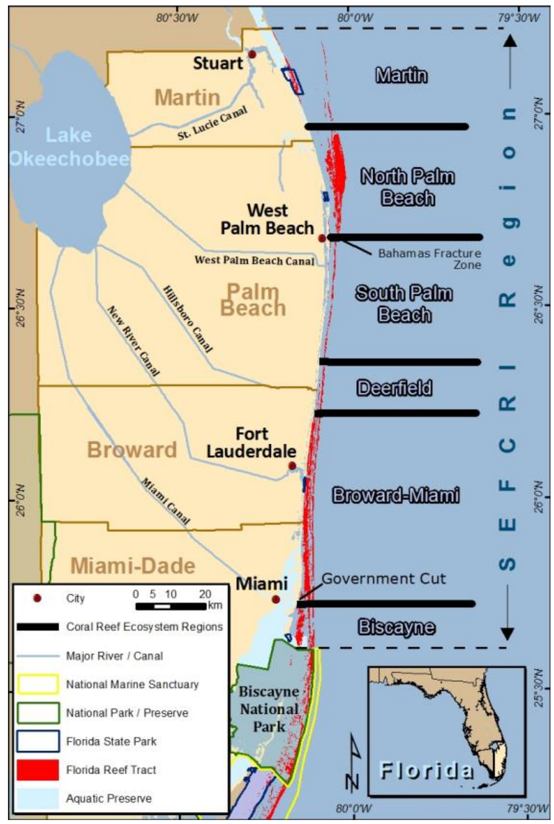

Figure 1. *Study area included all reef habitats between the northern boundary of Martin County to Government Cut in Miami-Dade County.*

The reef-scape was gridded into 100-m cells referred to herein as primary sampling units (PSUs). Each PSU was divided into four 50x50 m grid cells to acquire second-stage randomized data collection locations with the PSU (Figure 2). A PSU is synonymous with a "site" throughout the remainder of this document. At each second-stage data collection site multiple data collections (fish counts) occurred. During the analysis, an arithmetic mean for adjacent counts from each buddy team was calculated to determine the fish density per data collection area (177 m^2). This area is referred to herein as a second-stage unit (SSU). Each PSU and SSU was characterized by three main strata types, which combined are termed herein as map strata: coral reef ecosystem biogeographic subregion, benthic habitat type, and topographic slope (Table 1). The coral reef ecosystem biogeographic subregions as defined in Walker (2012) and Walker and Gilliam (2013) were used to divide the study area into ecologically relevant regions. The grid cells were characterized according to which region the majority of the unit resided. Benthic habitat maps from previous efforts were used to determine the majority habitat type in each PSU and SSU (Riegl et al., 2005; Walker et al., 2008; Walker, 2009; Walker, 2013). The benthic habitat maps contained more detail than was practical for the stratification, therefore *a priori* decisions were made to combine more specific habitats into broader strata (Table 2). Since topographic complexity also affects local fish distributions (Walker et al., 2009), topographic slope was included in the stratification as a surrogate for larger scale (10s of meters) topographic complexity. The slope was calculated in ArcGIS using high resolution LIDAR (Light Detection and Ranging) data. The LIDAR data were analyzed for slope where all areas greater than 5° were considered “high slope”. A single polygon layer of these areas was created and used to determine if the PSU and SSU majority were high or low slope.

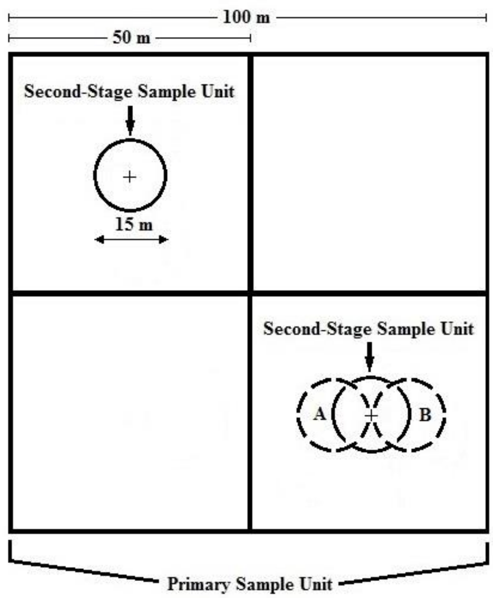

Figure 2. *Illustration of Primary Sample Unit (PSU) and Second-Stage Sample Units (SSUs). Selection of 2 individual target SSUs is accomplished by a randomization of the 4 cells within the PSU. The dashed circles represent a buddy pair (A and B). [modified from Smith et al., 2011]*

The map strata were used to parse the region into finer categories to optimize survey locations for the eight targeted fishery species. A pure randomized design would take many more surveys to acquire the necessary data on the desired species, whereas a strategically targeted design is much more efficient (Smith et al., 2011). In the Florida Keys, this strategy has been used effectively to optimize data collection by capturing the variability of species by habitat strata and allocating more sample sites to those strata with higher variation. In the case of the northern portion of the FRT, initially there was not much regional information available about the fisheries species to inform the survey design, thus the proportion of benthic habitats were used (Ault et al., 2012). Subsequent years used previously collected data to aid in the site allocations (see Figures 67-69). When including the biogeographic subregions, slope, and benthic habitat types, there were too many individual categories to be practical in the stratified random design and many were not thought to pertain to the targeted fish species. For example, the subtle differences between Colonized Pavement-Shallow and Ridge-Shallow benthic communities and geomorphology were not thought to be major factors affecting species distribution. Therefore certain benthic habitats were combined into what were intended to be more relevant strata, such as the nearshore habitats (NEAR). Combining the benthic habitats into habitat strata resulted in thirty-one map strata that were used in the sampling allocations (Table 1).

It was estimated that 360 PSUs could be visited each year with a combined effort from all partner agencies. Site allocations for each stratum were guided by the proportional distribution of strata in the sampling frame (Appendix 1). Each stratum was given a minimum of 5 sites. Then the remaining sites were distributed proportionally by the strata area. Extremely large strata were limited to 50 sites. There were no other special strata that needed to be accommodated within the SE FL area survey frame, unlike the FL Keys and Dry Tortugas annual surveys, which have been conducted largely within the boundaries of protected areas or special use zones. Once the total number of target sites for each stratum was determined, the corresponding number of PSUs was randomly chosen based on equal probability of selection from the survey frame using NOAA's sampling design tool for ArcGIS (http://coastalscience.noaa.gov/projects/detail?key=185). Then, two of the four SSUs in each chosen PSU were randomly selected. The center location of the two chosen SSUs were the sample sites for that PSU.

Table 1. *Map strata for the site randomization to optimize survey outcomes. The biogeographic subregions, habitat strata, and slope were used to define these areas. See Table 2 for habitat strata details.*

Subregion	**Habitat Strata**	**Slope**
Broward-Miami	INNR	High
Broward-Miami	INNR	Low
Broward-Miami	MIDR	High
Broward-Miami	MIDR	Low
Broward-Miami	NEAR	High
Broward-Miami	NEAR	Low
Broward-Miami	OFFR	High
Broward-Miami	OFFR	Low
Broward-Miami	PTDP	High
Broward-Miami	PTDP	Low
Broward-Miami	PTSH	N/D
Deerfield	MIDR	High
Deerfield	MIDR	Low
Deerfield	NEAR	Low
Deerfield	OFFR	High
Deerfield	OFFR	Low
Deerfield	PTDP	High
Deerfield	PTDP	Low
South Palm Beach	NEAR	Low
South Palm Beach	OFFR	High
South Palm Beach	OFFR	Low
South Palm Beach	PTDP	High

Subregion	Habitat Strata	Slope
South Palm Beach	PTDP	Low
South Palm Beach	PTSH	N/D
North Palm Beach	DPRC	High
North Palm Beach	DPRC	Low
North Palm Beach	NEAR	Low
Martin	NEAR	High
Martin	NEAR	Low
Martin	RGDP	High
Martin	RGDP	Low

Table 2. *Mapped benthic habitat classes and stratification habitat codes for this study, and major categories for the benthic habitat map in the southeast Florida region.*

Map Habitat Class	Habitat Strata
Deep Ridge Complex	DPRC
Linear Reef-Inner	INNR
Linear Reef-Middle	MIDR
Linear Reef-Outer	OFFR
Ridge-Deep	OFFR (RGDP in Martin only)*
Ridge-Shallow	NEAR
Other Delineations (Artificial, dredged inlets, sand borrow areas)	OTHR
Aggregated Patch Reef-Deep	PTDP
Aggregated Patch Reef-Shallow	PTSH
Patch Reef	PTSH <20m; PTDP >20m
Colonized Pavement-Deep	OFFR
Colonized Pavement-Shallow	NEAR
Unconsolidated Sediment	SAND
Scattered Coral/Rock in Sand	PTSH <20m; PTDP >20m
Seagrass	SGRS
Spur and Groove	OFFR
No Map Data	UNKW

*The Ridge-Deep was included in the OFFR strata for the southern portion of the reef tract, however in Martin County it was recognized as distinctly different and was thus kept as a separate stratum.

Throughout the four-county region, a total of 360 primary and 216 alternate sites were selected in 2012. For 2013, a slightly different strategy was employed, using 360 primary/core, 105 secondary/tier 2, and 216 alternate sites. Core target sites were prioritized and completed before the tier 2 sites to ensure a minimum number of sites in each stratum were targeted in case all the sites were not surveyed. Over the course of the 2013 field season almost every site on both the core and tier 2 lists were sampled. Due to the success of the 2013 sampling season, the secondary site strategy was abandoned in 2014, and 350 primary and 176 alternate sites were selected.

Prior to the beginning of field sampling, the target locations were visually inspected with the high-resolution bathymetry and benthic habitat maps in GIS to determine if the location was within the intended strata. If not, the points were moved (within the SSU where possible) to the designated target habitat. In cases where no suitable habitat was nearby, the point was discarded and a suitable alternate was chosen. Appendix 2 contains four site maps of actual survey locations from the combined 2012-2014 period. Appendix 3 contains four maps that illustrate the target locations and the actual survey locations for 2012. Survey targets without a corresponding “actual” location were not surveyed. This was more of a problem for sites located in the North Palm Beach and Martin County regions which were challenging to survey due to logistical factors (depth, strong currents). Appendix 4 contains four maps that illustrate the target and actual survey locations for 2013. These maps show “Core” and “Tier 2” target locations. Appendix 5 displays the targeted and actual locations for 2014.

3.2. Data Collection

Assessing population size and community level or species-specific trends of coral reef fishes is inherently difficult because of many factors. Reef fishes are speciose, exhibit various morphological and behavioral traits, have patchy distributions, and occur in heterogeneous and diverse habitats. These factors can make it difficult to determine optimal or standardized survey methods, and as a result many different visual survey methods have developed over time that are designed to provide researchers with the ability to assess fish populations at varying levels of precision. In recent years much progress has been made in regards to standardizing survey methodology among multiple academic, scientific and regulatory entities that routinely monitor and conduct research on the coral reefs found within the territorial waters of United States (Brandt et al., 2009). The most widely utilized method for assessing populations of coral reef fishes has become the stationary point-count (Bohnsack and Bannerot, 1986). During a point-count, the survey diver establishes a location at the center of an imaginary cylinder 15 m in diameter (177 m^2) that encircles a column of water that extends from the seabed to the sea surface. During a Reef Visual Census (RVC) point-count (RVC count and point-count are used synonymously throughout the remainder of this document), for the first five minutes only species names are recorded with the exception of any highly migratory or target species (groupers, snappers, etc.), which are enumerated as soon as they are seen. It is the species encountered during the first five minutes that are most critical for establishing a representative “snapshot” of the area as it existed when the divers entered the water. For the second five minutes, the numbers and size ranges (mean, min, max) (fork length) of each species are filled in, with new species being added to the list as they are encountered. Additional members of species that were observed during the first five minutes that enter the survey area after their initial observation are not recorded a second time.

All visual assessment methods have pros and cons/biases that are associated with the individual technique. Advantages of the RCV point-count method include: 1) its non-destructive nature, 2) the ability to be easily randomized, 3) fishery-independence, 4) the ability to observe and characterize the community as a whole, 5) production of data that are amenable to rigorous statistical analysis, and 6) the ability to be quickly and economically employed. Some items that are considered as potential biases of the RVC point-count method include the tendency to underestimate numbers of fish, especially in terms of density and diversity of small, cryptic fishes and sometimes exceptionally abundant fishes; especially in highly complex habitats. However, one of the goals of a well-designed fishery-independent monitoring program is to establish and maintain a consistent sampling method which will track and quantify relative changes in abundance/density/species richness/diversity over space and time. The RVC method meets the goals of generating useful data with minimal to moderate logistical requirements. Creating a completely accurate representation of a complex biological community is neither an essential goal for most management needs, nor a realistic goal due to the stochastic nature of community structure. The stratified sampling design implemented in this project is specifically designed to generate sample sizes adequate to allow for meaningful statistical comparisons within the observed range of abundance levels.

Task methodology followed established methods from the FDEP-CRCP Project 3A report: Development of a Coral Reef Fishery-Independent Assessment Protocol for the Southeast Florida Region (Ault et al., 2012), and RVC report: A Cooperative Multi-agency Reef Fish Monitoring Protocol for the Florida Keys Coral Reef Ecosystem (Brandt et al., 2009). Fishery-independent assessment protocol on all habitats included a rapid characterization of multiple benthic habitat features with each point-count. Divers were equipped with a standardized 1-meter “All Purpose Tool” (APT) that was used to aid in size estimation of fishes and assessment of the benthos. Benthic habitat features surveyed after each point-count included: substrate slope, max vertical hard and soft relief, surface relief coverage of hard and soft features, abiotic footprint, biotic cover by major organismal category, habitat type, underwater visibility, water temperature, cylinder radius, and current strength (Brandt et al., 2009).

Abundance and distribution of reef fishes has been shown to fluctuate on a seasonal basis within the SEFCRI area, with greater abundances for many species being the norm during the summer months (Bohnsack et al., 1994; Sherman et al., 1999; Walker et al., 2002; Jordan et al., 2004). Therefore, data collection took place only within the months of May through October in each year. The percentage of sites sampled during each month of the sampling season is broken down as follows:
2012 – May (0%), June (0%), July (12%), August (31%), September (30%), October (27%)
2013 – May (3%), June (16%), July (20%), August (26%), September (22%), October (13%)
2014 – May (7%), June (21%), July (12%), August (31%), September (14%), October (15%)

During the combined 2012-2014 sampling seasons, a grand total of 864 PSUs were surveyed over the course of 3,320 dives. In 2012, 42 divers from 7 partner agencies conducted 881 individual dives, completing surveys at 232 sites (PSUs). In 2013, 34 divers from 6 partner agencies conducted 1,226 individual dives, completing surveys at 324 sites. In 2014, 35 divers from 6 partner agencies conducted 1,213 individual dives, completing surveys at 308 sites. For a detailed breakdown of number of SSUs sampled from each ecological subregion and strata by year, see Appendix 1. The total number of sites and percent contribution made by each agency each year (Table 3) does not account for the contribution that divers from a specific agency may have made while diving from other partner agency vessels in order to increase sampling efficiency.

Table 3. *Yearly sampling effort for each partner agency and combined totals.*

Agency	2012 # of sites (%)	2013 # of sites (%)	2014 # of sites (%)	Total # of sites (%)
NSUOC	163 (70%)	192 (59%)	202 (66%)	557 (64.5%)
NOAA-SEFSC	19 (8%)	87 (27%)	0 (0%)	106 (12.3%)
FWC Tequesta	7 (3%)	16 (5%)	50 (16%)	73 (8.4%)
FDEP-CRCP	16 (7%)	16 (5%)	23 (7%)	55 (6.4%)
Miami-Dade County	15 (6%)	7 (2%)	24 (8%)	46 (5.3%)
Broward County	10 (4%)	6 (2%)	9 (3%)	25 (2.9%)
FDEP-ERP	2 (1%)	0 (0%)	0 (0%)	2 (0.2%)
Totals	232	324	308	864

3.3. Data Entry and Proofing

Efforts to ensure maximum quality of the data were maintained throughout all levels of the data collection, entry, and verification process in order to create the most accurate database possible. This began with a review of the data sheet immediately following each dive, during which the diver consulted with their dive buddy and the other dive team (when applicable) about each entered variable to detect questionable or unreasonable entries, discrepancies, or missing data. Divers were encouraged to enter their data as soon as possible upon returning from the field, ideally the same or next day, but no longer than one week in order to give the diver the ability to best recall the specifics of each dive, detect any potential errors that were not caught on the boat, and prevent errors that would be caused by rushing to enter a large amount of data from an entire season at the last minute. Upon reaching the end of the sampling season, the lead data manager from each partner agency was responsible for generating proofing sheets which served as an aid to finding and correcting errors to the dataset during the quality assurance/quality control process. Once all errors were identified and corrected, the final version of the data (i.e., sample, species, and substrate files, boat log, diver log, and environmental data) for each agency was submitted to NSUOC for the final data merge and verification procedures. Once final data from each agency were compiled, the RVC Annual Master Spreadsheet file was created. This file consisted of merged (via Merge2.0.exe program) ASCII sample, substrate and species data outputs from the RVC data entry program, along with a combined version of the Boat/Field and Water Quality/Environmental logs, each of which became one of four individual worksheets within the completed RVC Annual Master Spreadsheet file. The next step involved performing an in-depth cross check of each of the four worksheets to locate any missing samples or incorrectly entered data, outliers, unlikely sizes and numbers of particular species, and any other dubious entries. Questionable elements discovered during this process were typically resolved by contacting the individual diver(s) who collected the data. A final rigorous verification procedure followed which scrutinized the habitat and substrate data, comparing the observed results to the GIS database.

3.4. Data Analysis

A descriptive ecological analysis that includes species inventory, density, and frequency of occurrence of all fish species observed was performed on the 2012-2014 dataset. This analysis followed established methods from a previous RVC report (Brandt et al., 2009). Each of the aforementioned metrics was partitioned by individual strata (subregion, habitat type, and slope). Density is reported in terms of mean "SSU Density", which is the average of the data collections conducted in each secondary survey location (usually 2, rarely 1 or 3). This standardized each data collection to a single area of 177 m^2. For analyses presented in this report, species that were recorded past the 10 minute mark during a survey were omitted. In addition, an initial exploration into the trends of distribution and abundance throughout the greater Florida Reef Tract (combining data from the northern portion of the FRT with that from the FL Keys and Dry Tortugas) of select species was undertaken.

Of particular interest in the northern portion of the FRT, and one of the primary motivating factors for this program, is the population status of commercially and recreationally important reef fish species. Therefore a selection of eight target species (based on their status as species of commercial and/or recreational importance and their estimated level of exploitation in southeast Florida) were examined for an in-depth evaluation of average density and percent occurrence at different life-stages (pre-exploited and exploited) and average length of the exploited phase individuals. The minimum legal size limit or size at reproductive maturity (for unregulated species) was used as a measure for pre-exploited versus exploited and varied by species (Table 4). Fish with a fork length (FL) less than the specified length were considered as "pre-exploited" (not targeted in recreational or commercial fishing) and larger fish as "exploited". The species were: Gray Triggerfish (*Balistes capriscus*), Red Grouper (*Epinephelus morio*), White Grunt (*Haemulon plumierii*), Bluestriped Grunt (*Haemulon sciurus*), Hogfish (*Lachnolaimus maximus*), Mutton Snapper (*Lutjanus analis*), Gray Snapper (*Lutjanus griseus*), and Yellowtail Snapper (*Ocyurus chrysurus*).

Table 4. *List of commercially and recreationally important species' exploited lengths.*

Species	Length (cm)
Gray Triggerfish, *Balistes capriscus*	35
Red Grouper, *Epinephelus morio*	50
White Grunt, *Haemulon plumierii*	20
Bluestriped Grunt, *Haemulon sciurus*	20
Hogfish, *Lachnolaimus maximus*	30
Mutton Snapper, *Lutjanus analis*	40
Gray Snapper, *Lutjanus griseus*	25
Yellowtail Snapper, *Ocyurus chrysurus*	25

4. RESULTS AND DISCUSSION

4.1. Fish Assemblage

Over the course of the three-year study period, 563,311 individual fish of 289 species were observed (216 in 2012, 254 in 2013, and 244 in 2014). There were 16 species observed in 2012 that were not encountered in 2013, and 54 species that were observed in 2013 that had not been encountered in 2012. In 2014 there were 10 species observed that were not seen in either of the previous 2 years, and 43 species that were seen in one or both of the first two years that were not seen in the third. Comparatively, 214 species have been recorded from 13 years of annual monitoring (2001-2013) at repeated monitoring sites within Broward County (Gilliam et al., 2014) and a compiled total of 354 species (although not all reef associated) have been recorded in marine habitats in Broward County from multiple projects over the course of the past 10+ years (Spieler et al., unpublished data).

4.1.1. Fish Density

Total mean density for all sites and strata combined for all three years was 170 ±5.9 SEM fishes/SSU. For 2012 mean density was 151 ±6.9 fishes/SSU, in 2013 it was 168 ±12.4 fishes/SSU, and in 2014 it was 186 ±8.2 SEM. Fish density was higher on high-slope strata. If low and high slope strata are compared within each individual habitat, mean density was higher in all three years for the high slope strata with the exception of RGDP-High which was not sampled in 2012 (Figures 3, 4). It is also worth noting that the spike in density for the RGDP-high stratum is largely attributable to the presence of high numbers of Mackerel and Rough Scad (*Decapterus macarellus* and *D. punctatus,* respectively) in 2013.

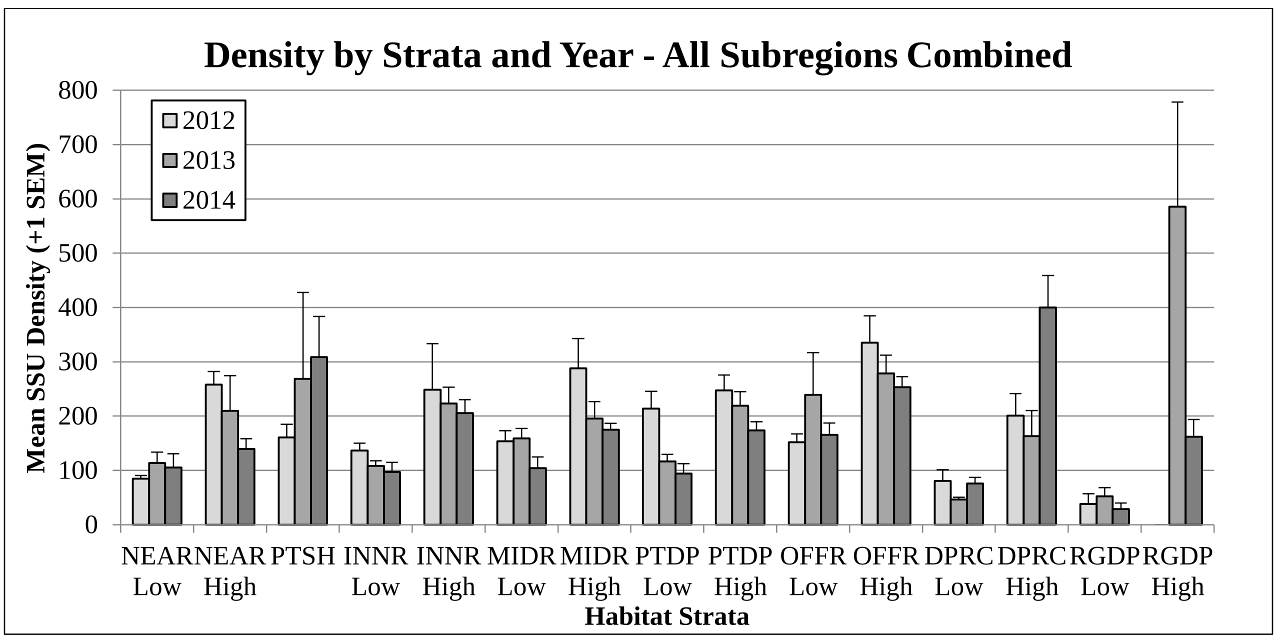

Figure 3. *Mean SSU density by strata, unfiltered data (including all species observed). N=2012,2013,2014: NEAR-low (N=129,146,40), NEAR-high (N=8,16,100), INNR-low (N=41,33,8), INNR-high (N=4,12,44), PTSH (N=20,8,10), MIDR-low (N=68,50,8), MIDR-high*

(N=7,20,89), OFFR-low (N=66,71,16), OFFR-high (N=28,86,120), PTDP-low (24,33,6), PTDP-high (N=13,41,29), DPRC-low (N=19,82,61), DPRC-high (N=3,12,42), RGDP-low (N=2,18,3), RGDP-high (N=0,11,29).

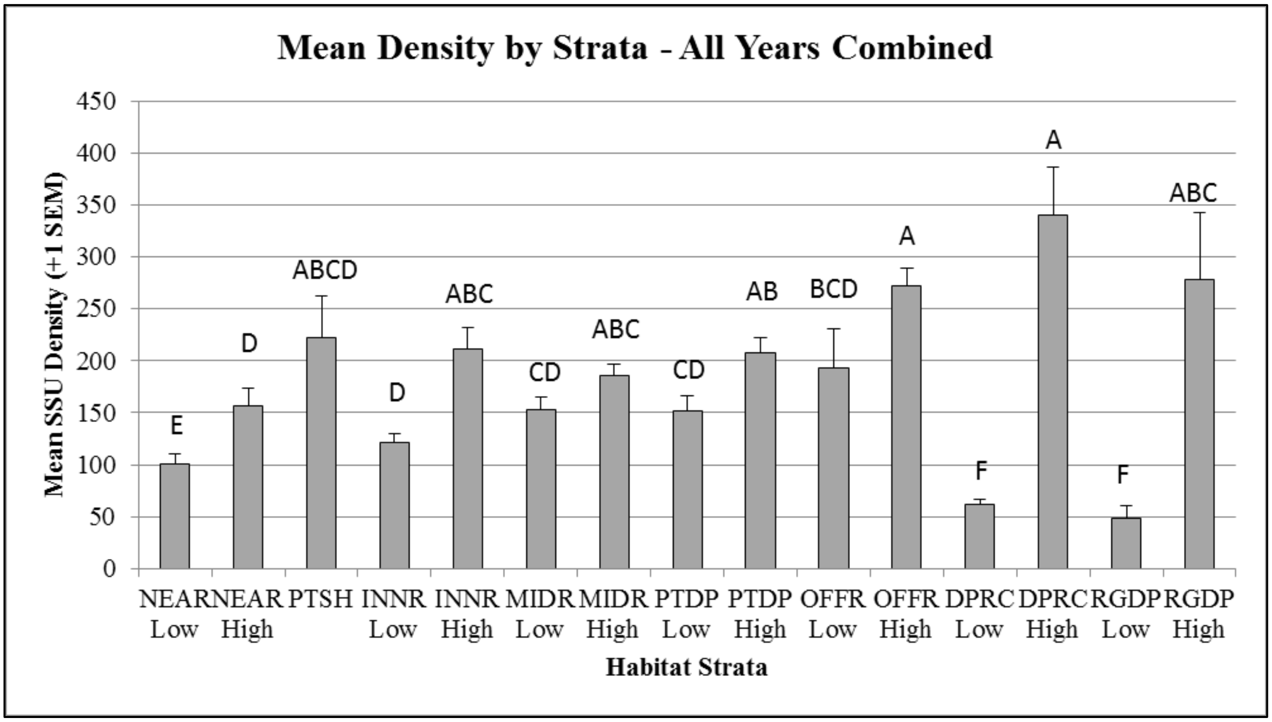

Figure 4. *Mean SSU density by habitat strata, all three years combined. Letters above the bars indicate homogenous groupings (SNK, p<0.05). NEAR-low (N=315), NEAR-high (N=124), INNR-low (N=82), INNR-high (N=60), PTSH (N=38), MIDR-low (N=126), MIDR-high (N=116), OFFR-low (N=153), OFFR-high (N=234), PTDP-low (N=63), PTDP-high (N=83), DPRC-low (N=162), DPRC-high (N=57), RGDP-low (N=23), RGDP-high (N=40).*

4.1.2. Fish Species Richness

Mean species richness for all sites and strata combined for both years was 25.0 ±0.23 species/SSU, and remained fairly similar between the three years of the study. For 2012 mean species richness was 27 ±0.45 species/SSU, in 2013 it was 24.5 ±0.39 species/SSU, and in 2014 it was 26.0 ±0.39 species/SSU. Similar to mean density, when strata were compared, fish richness was higher on high slope in every instance except for RGDP-high which was not sampled in 2012 (Figure 5). The northern subregions (Martin and North Palm Beach) had significantly lower species richness than those further south (SNK, p<0.05) (Figure 6), which is consistent with the differences in habitat structure, slope, and water temperature.

In general, species richness was higher in 2012 for every habitat strata. It is unlikely the higher species richness is based on differences among individual counters. The same divers counted many of the same strata both years. Also it is unlikely the difference is an artifact of differences in diver identification skills as less-experienced divers are less likely to recognize and differentiate between species so it would be anticipated 2012 would have lower species counts than 2013. Year-to-year differences in species richness are not uncommon (Kilfoyle et al., 2013).

Interestingly, Gilliam et al. (2014) documented overall higher abundance and species richness of reef fishes in 2013 as compared to 2012 and every year prior. However, that study used transect surveys in addition to point-counts, and therefore inherently includes higher numbers of cryptic species and juveniles than the current study. Surveys for the Gilliam et al. (2014) study took place on a limited number of habitats as well, and therefore it was not able to provide the same kind of community level assessments on the number of habitats that are targeted in this study.

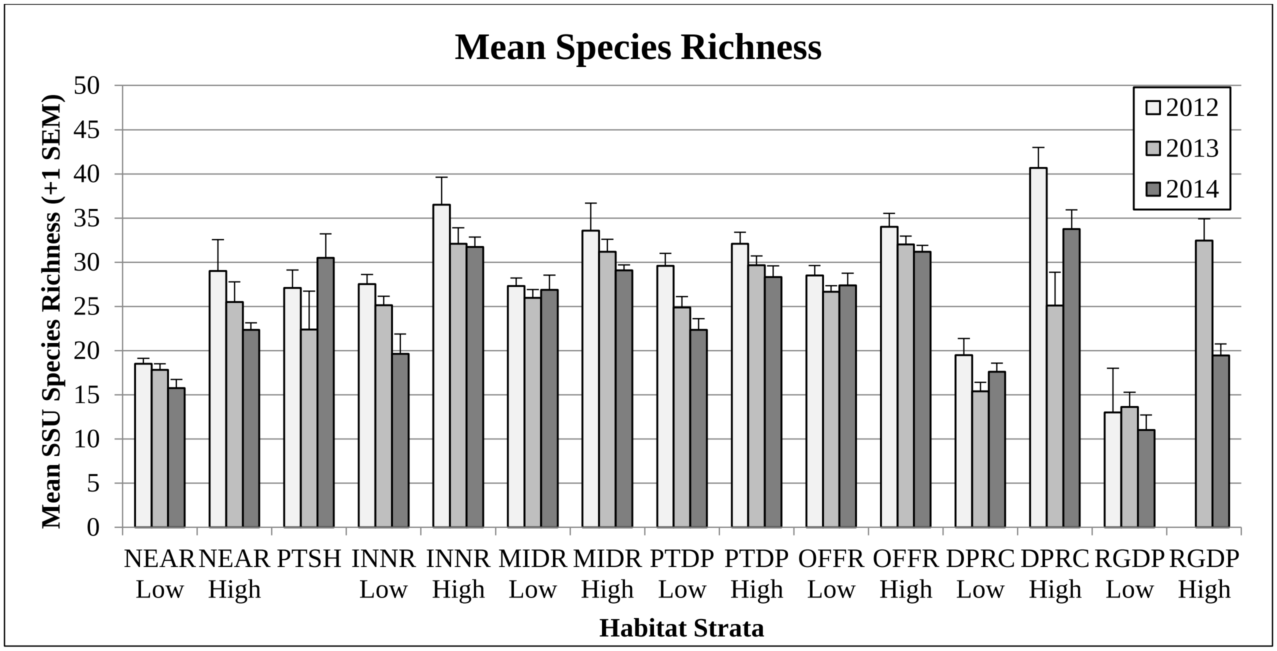

Figure 5. *Species richness by habitat strata. NEAR-low (N=129,146,40), NEAR-high (N=8,16,100), INNR-low (N=41,33,8), INNR-high (N=4,12,44), PTSH (N=20,8,10), MIDR-low (N=68,50,8), MIDR-high (N=7,20,89), OFFR-low (N=66,71,16), OFFR-high (N=28,86,120), PTDP-low (24,33,6), PTDP-high (N=13,41,29), DPRC-low (N=19,82,61), DPRC-high (N=3,12,42), RGDP-low (N=2,18,3), RGDP-high (N=0,11,29).*

The top 10 most abundant species averaged over all three years were, in order of decreasing SSU density ($\bar{D}$): Bicolor Damselfish (*Stegastes partitus*), Bluehead Wrasse (*Thalassoma bifasciatum*), Masked/Glass Goby (*Coryphopterus pesonatus/hyalinus*), unidentified/juvenile Grunts (*Haemulon* spp.), Tomtate (*Haemulon aurolineatum*), Slippery Dick Wrasse (*Halichoeres bivitattus*), Yellowhead Wrasse (*Halichoeres garnoti*), Ocean Surgeonfish (*Acanthurus bahianus*), French Grunt (*Haemulon flavolineatum*), and Redband Parrotfish (*Sparisoma aurofrenatum*).

In terms of frequency of occurrence ($\bar{P}$), the list is fairly similar to the top 10 most abundant species, with 5 out of 10 species being present on both lists. In decreasing order: Sharpnose Pufferfish (*Canthigaster rostrata*), Ocean Surgeonfish (*Acanthurus bahianus*), Bluehead Wrasse (*Thalassoma bifasciatum*), Bicolor Damselfish (*Stegastes partitus*), Slippery Dick Wrasse (*Halichoeres bivitattus*), Doctorfish (*Acanthurus chirurgus*), Redband Parrotfish (*Sparisoma aurofrenatum*), Yellowhead Wrasse (*Halichoeres garnoti*), Greenblotch Parrotfish (*Sparisoma atomarium*), and Blue Tang (*Acanthurus coeruleus*).

Following the 2012 surveys, seven species not previously recorded in the FL Keys or Dry Tortugas RVC surveys were added to the master species list that is used for the RVC data entry program. Those species are: Spotted Burrfish (*Chilomycterus reticulatus*), Atlantic Bumper (*Chloroscombrus chrysos*), Flying Gurnard (*Dactyloscopus volitans*), Sharptail Eel (*Myrichthys breviceps*), Goldspotted Eel (*Myrichthys ocellatus*), Atlantic Guitarfish (*Rhinobatos lentiginosus*), and Black Brotula (*Stygnobrotula latebricola*). Following the 2013 surveys, the following seven species were added to the list: Whitebone Porgy (*Calamus leucosteus*), Black Seabass (*Centropristis striata*), Mottled Mojarra (*Eucinostomus lefroyi*), Oyster Toadfish (*Opsanus tau*), Blackwing Searobin (*Prionotus rubio*), Banded Rudderfish (*Seriola zonata*), and Rough Scad (*Trachurus lathami*). Following the 2014 surveys, eight species were added to the list: Dwarf Goatfish (*Upeneus parvus*), Tiger shark (*Galeocerdo cuvier*), Chestnut Moray (*Enchelycore carychroa*), Red Snapper (*Lutjanus campechanus*), Palometa (*Trachinotus goodei*), Cownose Ray (*Rhinoptera bonasus*), Freckled Soapfish (*Rypticus bistripinnus*), and Bank Seabass (*Centropristis ocyurus*). The porgy and both seabasses are considered as temperate/subtropical species that, logically, were found in the northern portion of the survey area.

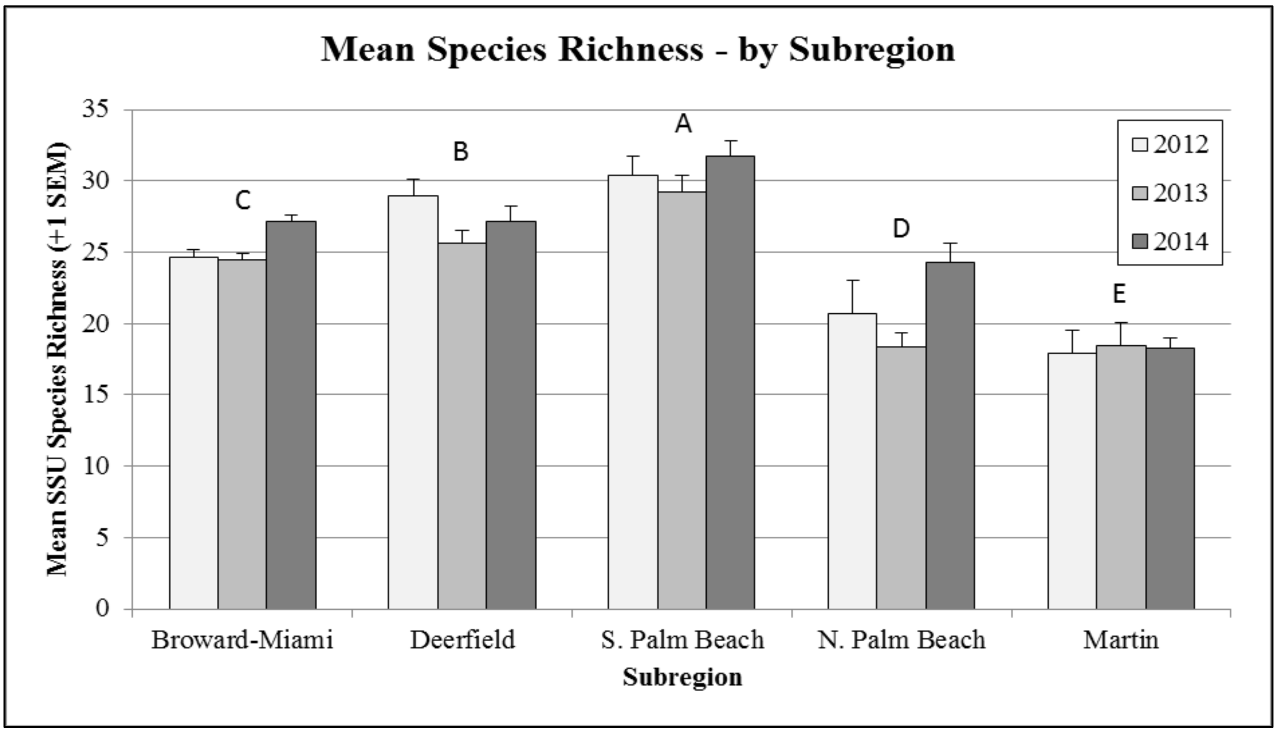

Figure 6. *Species richness broken down by biogeographic subregion. Letters above the bars indicate homogenous groupings (SNK, p<0.05). Broward-Miami (N=277,320, 292), Deerfield (N=75, 90, 61), South Palm Beach (N=40, 78, 70), North Palm Beach (N=26,106, 104), Martin (14, 45, 78).*

4.1.3. Fish Community Regional Habitat Associations

Multivariate analyses showed patterns in the reef fish communities associated with benthic habitats (Figure 7). Surveys in many of the habitats clustered tightly indicating that the communities at these sites were similar to each other. These included Linear Outer Reef (LIRO), Spur and Groove (SPGR), Colonized Pavement Deep (CPDP), Aggregated Patch Reef Deep (APRD), and Linear Reef Middle (LIRM). As indicated by their spread away from each other and the main cluster of points, other habitats contained more variable but relatively distinct communities. For example the Ridge Deep (RGDP) and Deep Ridge Complex (DPRC) were spread out and mostly separated from surveys in other habitats. The Ridge Shallow (RGSH) and Colonized Pavement Shallow (CPSH) were also spread out, however they were comingled indicating that the communities in these habitats, although variable, are more similar to each other than other habitats. These results agree with previously reported analyses on a large dataset for northern Broward County (Walker et al., 2009). Walker et al. (2009) found that fish communities were more tightly clustered in the deeper communities and more variable in the shallow. They also found that the communities on the shallow Ridge and Colonized Pavement were not statistically different and therefore considered a habitat classification higher up the hierarchy that combines those two habitats, the Nearshore Ridge Complex. Based on both Walker et al. (2009) and this study, it appears that combining the communities on the deeper habitats CPDP, LIRO, SPGR, APRD, and perhaps LIRM could be warranted.

A cluster analysis of all SSUs (2012 – 2014) illustrated the similarity of each site to each other in a dendrogram (Figure 8). The dendrogram showed a main split in the data at the 36% similarity level indicating the sites in these two clusters were very different. The sites associated with these clusters were categorized as Cluster A and Cluster B and plotted in GIS to visualize their spatial relationships (Figure 9). There was clear spatial separation in two clusters where Cluster A was mainly offshore spread from the Broward-Miami through South Palm Beach subregions. Cluster B was mainly constrained to the nearshore in the Broward-Miami region. The SSU's in Cluster A and B were associated with different habitat types (Figure 10). The SSU's in Cluster A mainly occurred in the deep habitats (APRD, CPDP, DPRC, LIRM, LIRO, PTCH, RGDP, SCRS, and SPGR) whereas Cluster B SSU's were associated with mostly shallow habitats (RGSH, CPSH, and LIRI) supporting that depth was a strong determinant of the differences in the regional assemblage. When categorized by shallow and deep habitats, the MDS illustrated a tight cluster of deep SSU's and that the shallow SSU's were separate, although spread out considerably indicating high variability (Figure 11). However there were many deep SSU's spread throughout the shallow SSU's as well, indicating the depth was not the only factor. When combining habitats into general categories of Reef (LIRI, LIRM, LIRO, APRD, and PTCH) and Hardbottom (RGSH, CPSH, DPRC, CPDP, RGDP, and SCRS), the MDS revealed that the Reef SSU's were mostly tightly clustered and the Hardbottom SSU's were mostly separate and spread throughout the plot where the Deep and Shallow MDS sites mixed (Figure 12). This result indicated that the main differences in habitat associated with fish assemblages was whether it was deep or shallow reef or hardbottom. When displayed by both depth and general habitat, the MDS illustrated good splits between most categories (Figure 13). However some assemblages on Deep Hardbottom sites clustered with those on the Deep Reef sites. The MDS was then categorized by Depth, General Habitat and Slope (0=Low, 1=High, 2=Not Defined) (Figure 14).

The general patterns in Figure 13 remained and high slope helped explain the Deep Hardbottom sites clustering with the Deep Reef sites, however others were spread throughout.

Since Ferro et al. (2005), Walker et al. (2009), and this study's results indicated depth is one of the primary determinants of fish community structure, the data were analyzed separately for surveys that occurred in deep habitats and shallow ones. Among the deep habitat surveys, a similar pattern emerged in the MDS with a tightly clustered area of sites and many others spread throughout much of the graph (Figure 15). The potential causes of this pattern were fully elucidated when categorizing the surveys by the coral reef ecosystem regions of Walker (2012) and Walker and Gilliam (2013). The Reef sites clustered most tightly together regardless of slope or ecosystem region indicating a high similarity between the communities. Reef sites only occurred in the Broward-Miami, Deerfield, and South Palm Beach regions. The North Palm Beach High Slope Hardbottom sites also clustered with the Reef sites indicating that the higher relief hardbottom areas extending into Lake Worth and Jupiter (e.g. Jupiter Ledges) have similar communities as the Reefs further south. This is evident in the SIMPER comparison between these groups (Table 5) where species mean abundances were much more similar between South Palm Beach High Slope Reef and North Palm Beach High Slope Hardbottom than South Palm Beach High Slope Reef and North Palm Beach Low Slope Hardbottom. These SSUs can be seen as the green Cluster A sites spread out in the North Palm Beach region in Figure 9. Although much less clustered, the Martin High Slope Hardbottom and North Palm Beach Low Slope Hardbottom sites separated out from each other and most other sites indicating different communities in these areas as well. Table 6 shows the analysis of similarity (ANOSIM) pairwise comparisons between fish communities in each combined factor. Of the total 189 pairwise comparisons, 95 had a significance…*(continued on page 39)*

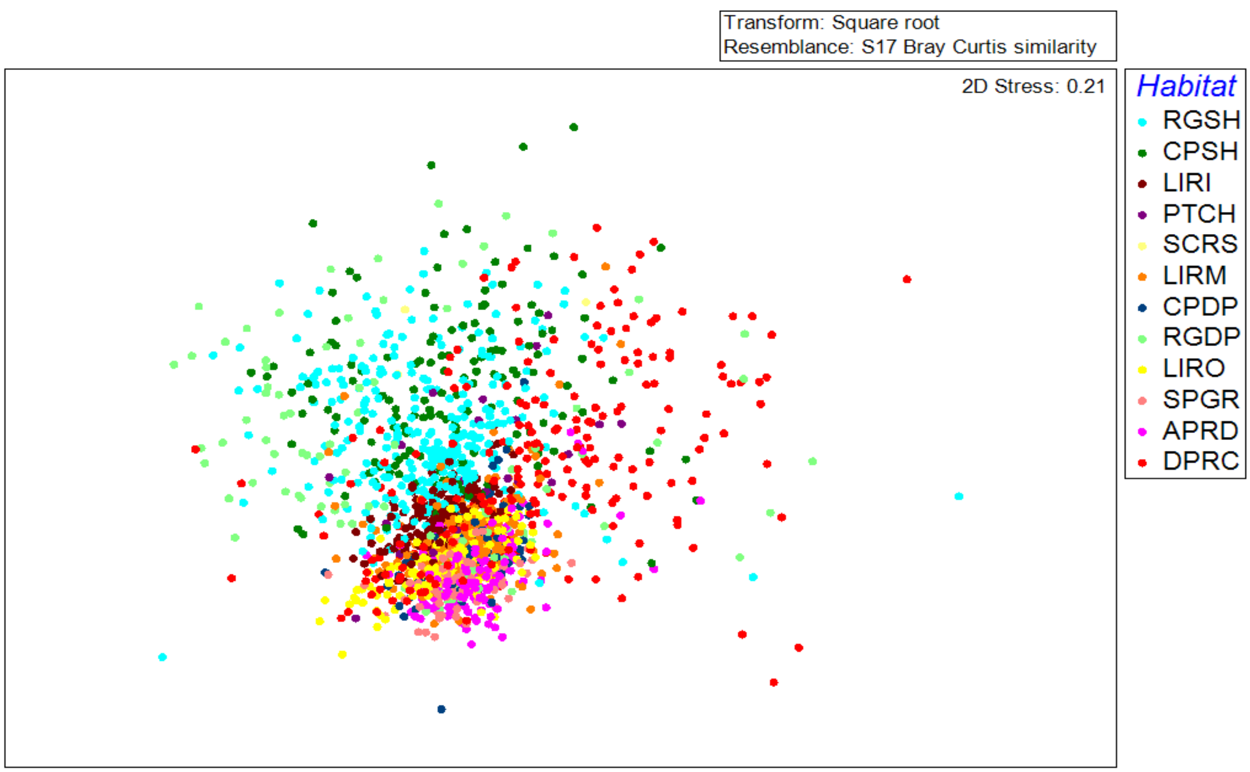

Figure 7. *MDS plot of all RVC SSUs (2012 – 2014) categorized by Habitat.*

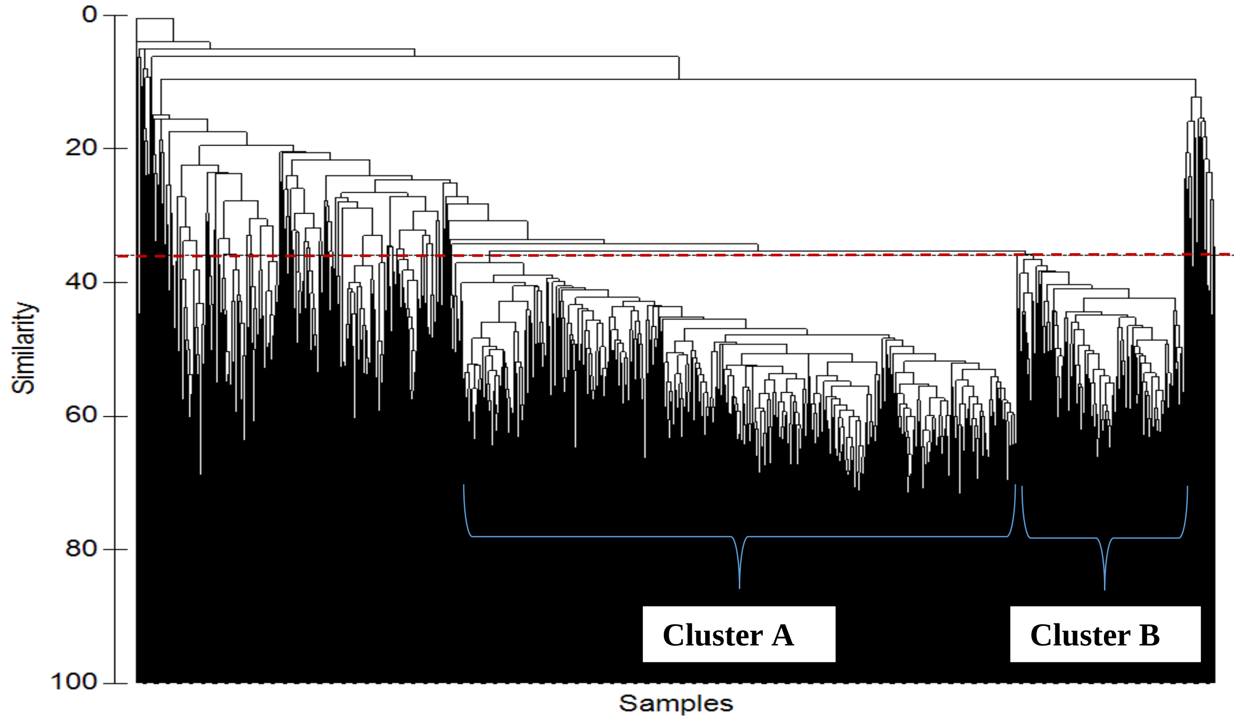

Figure 8. *Cluster dendrogram of all RVC SSUs (2012 – 2014). Dashed red line indicates the 36% similarity level which is the main split in the data. All sites linked below the left cluster are Cluster A and all sites linked below the right cluster are Cluster B.*

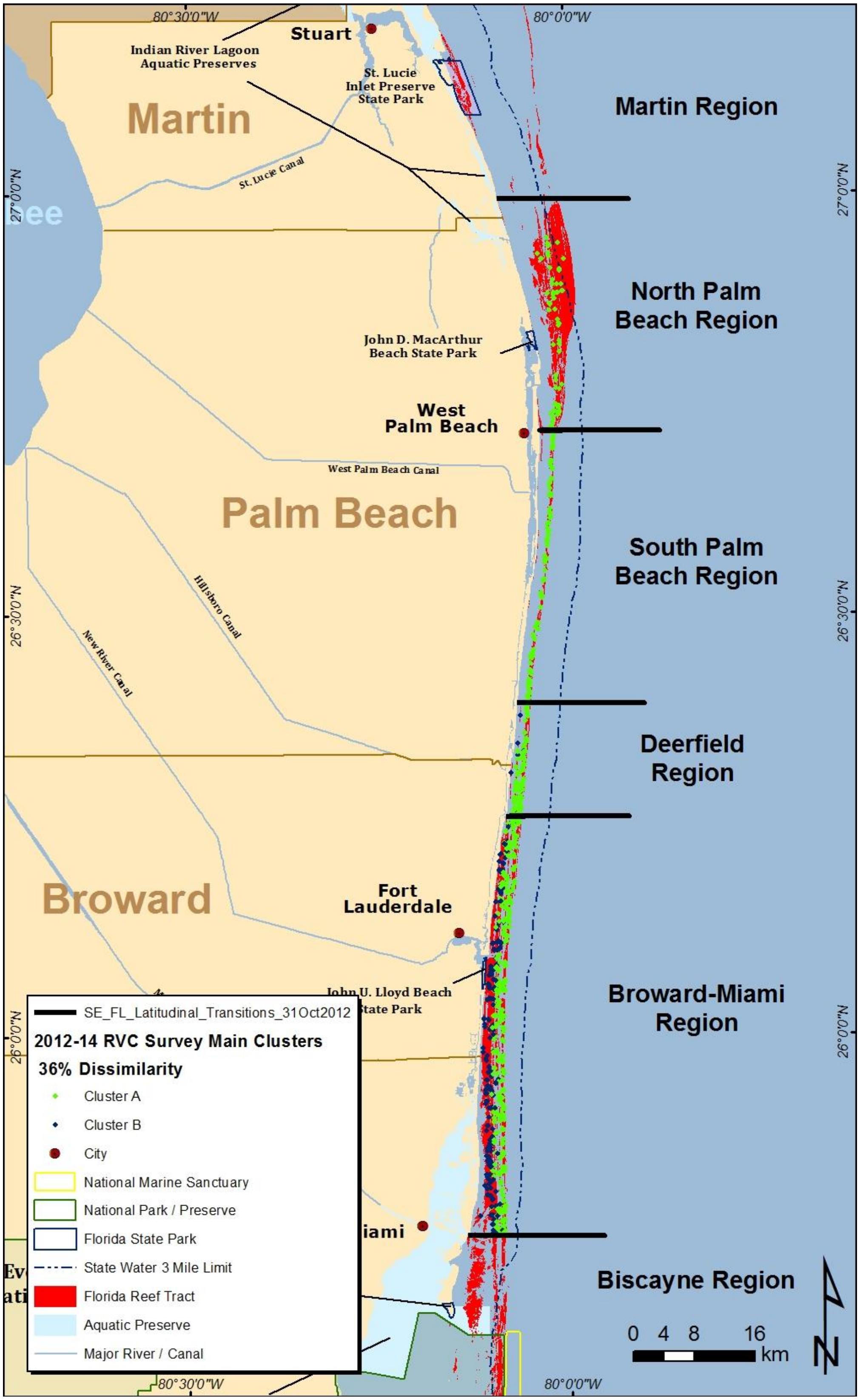

Figure 9. *Map of all RVC SSUs (2012 – 2014) illustrating the sites within the two main clusters of species densities in the multivariate analysis at 36% similarity.*

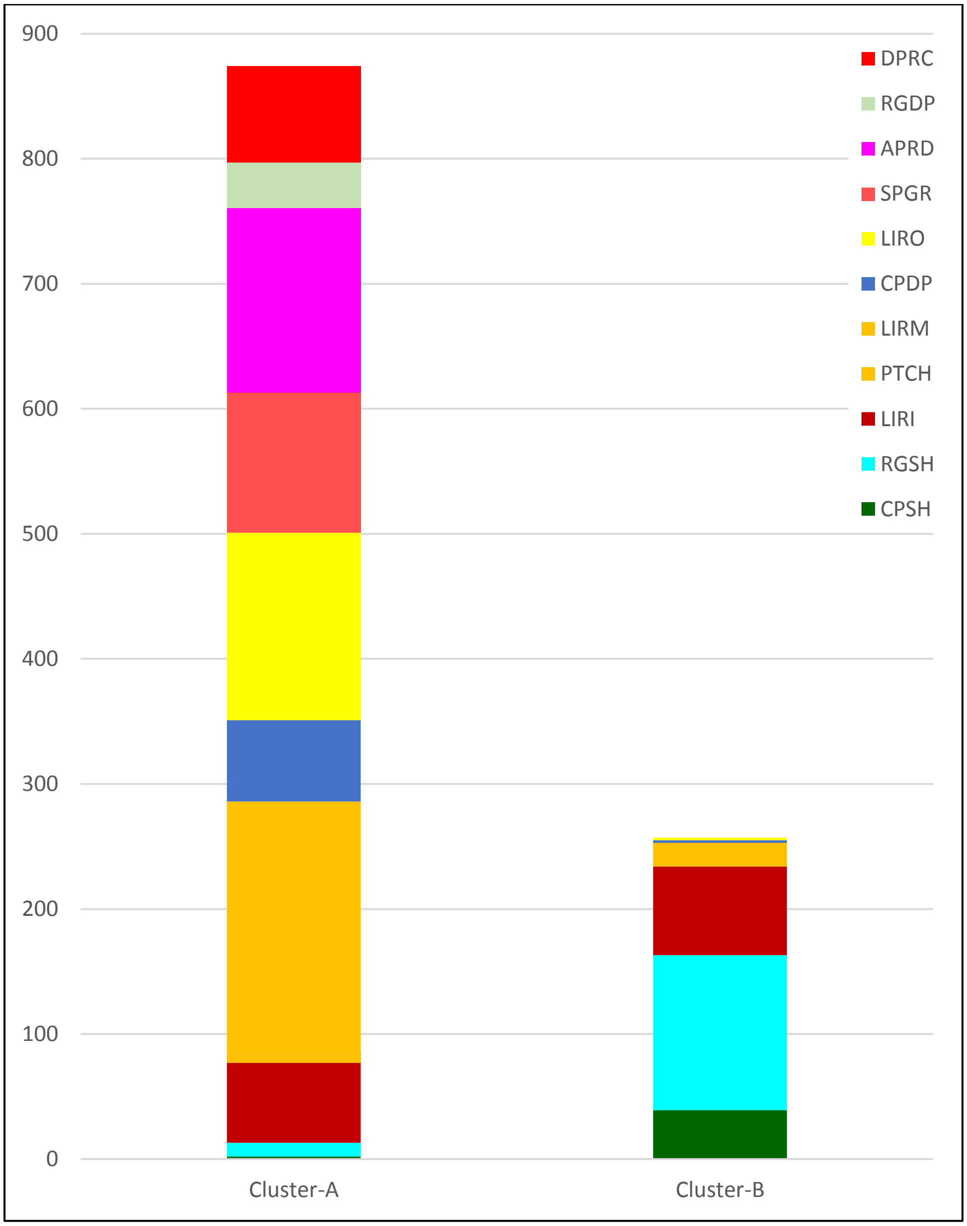

Figure 10. *The number of SSU's in the two main clusters of species densities in the multivariate analysis at 36% similarity by habitat type. Cluster A was dominated by deeper habitats and Cluster B was dominated by shallow ones.*

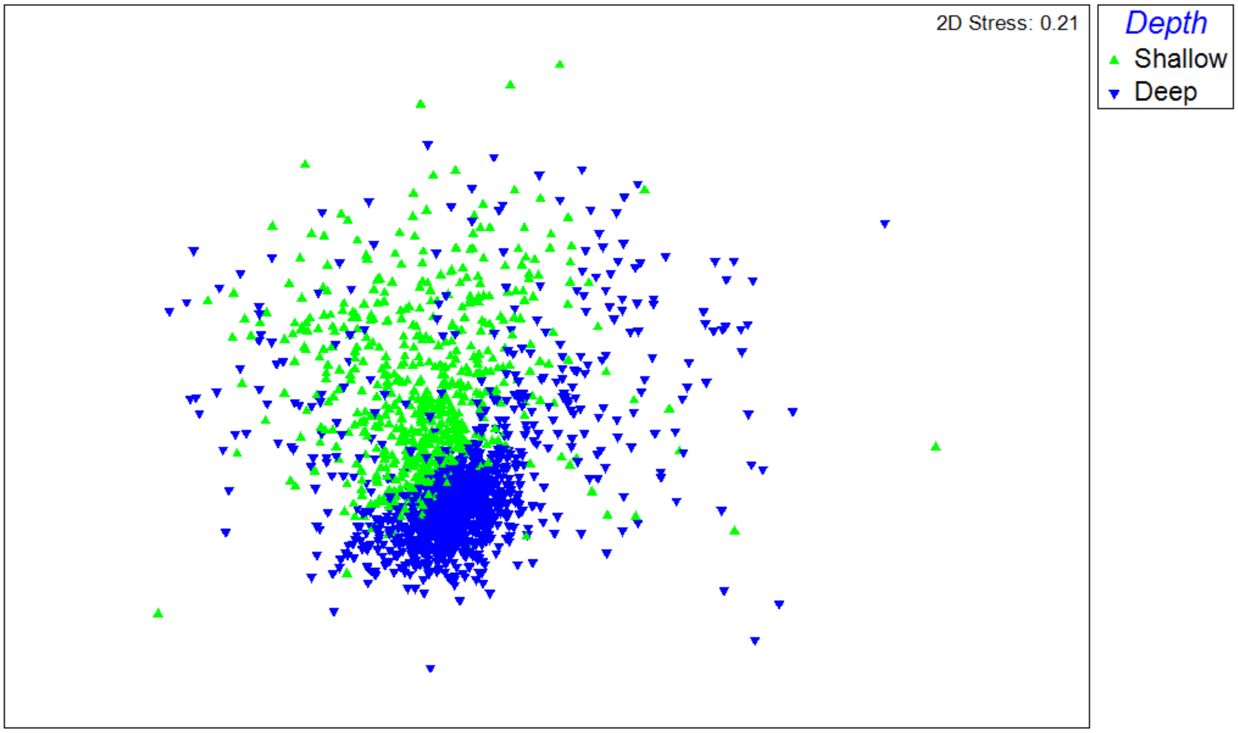

Figure 11. *MDS plot of all RVC SSUs (2012 – 2014) categorized by Habitat Depth. Shallow Colonized Pavement, Shallow Ridge and Inner Reef habitats were categorized as Shallow and all others as Deep.*

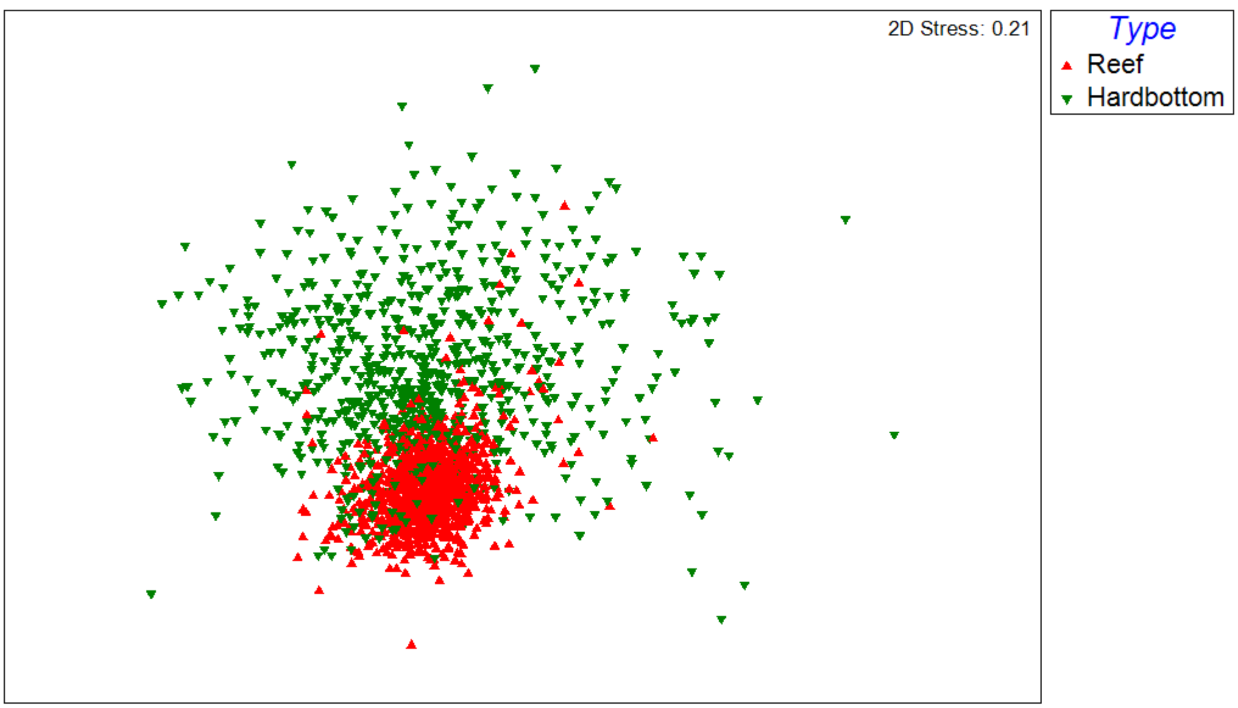

Figure 12. *MDS plot of all RVC SSUs (2012 – 2014) categorized by Reef or Hardbottom. Inner, middle, and outer reef habitats were categorized as Reef and all pavement and ridge sites were categorized as Hardbottom.*

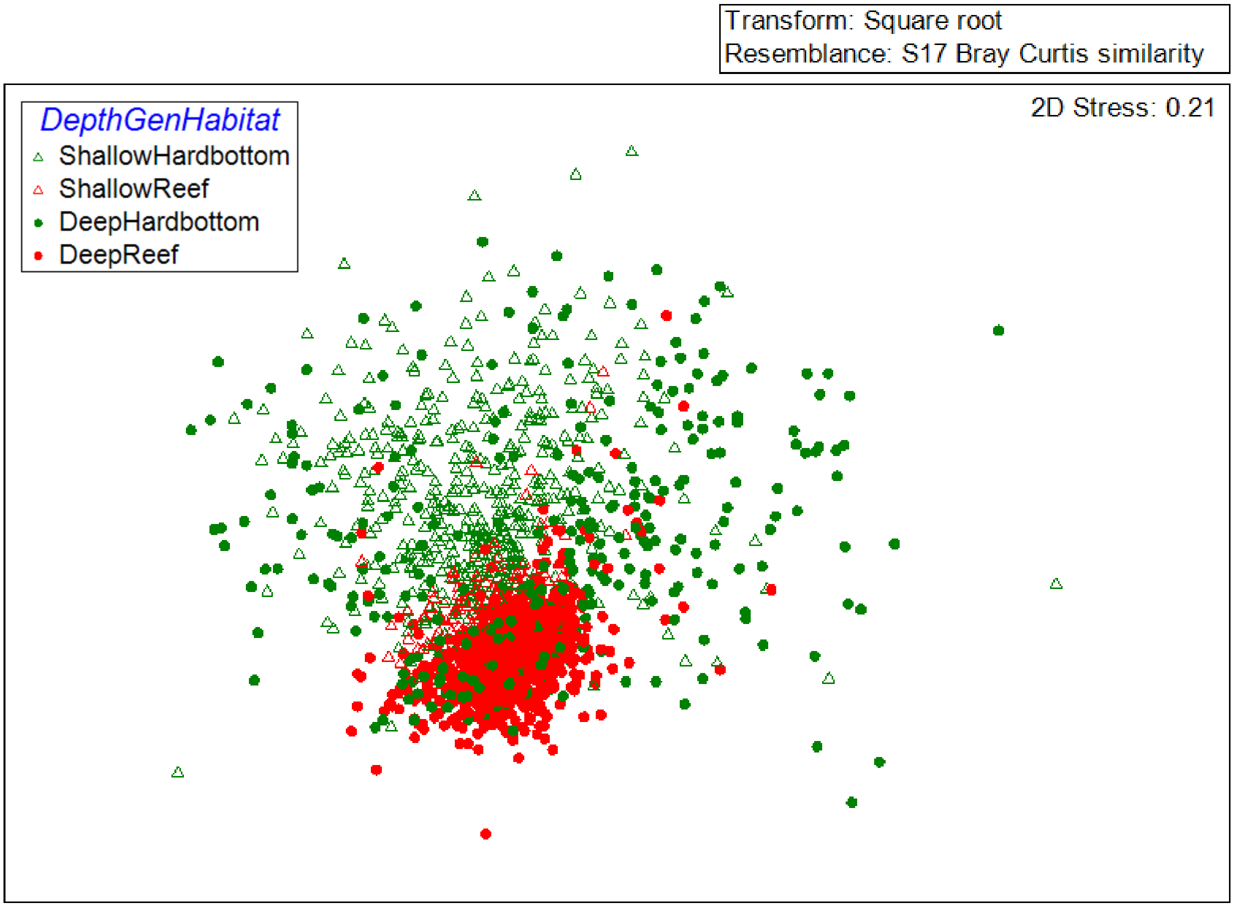

Figure 13. *MDS plot of all RVC SSUs (2012 – 2014) categorized by Depth and Reef or Hardbottom. Some Deep Hardbottom sites clustered with the Deep Reef.*

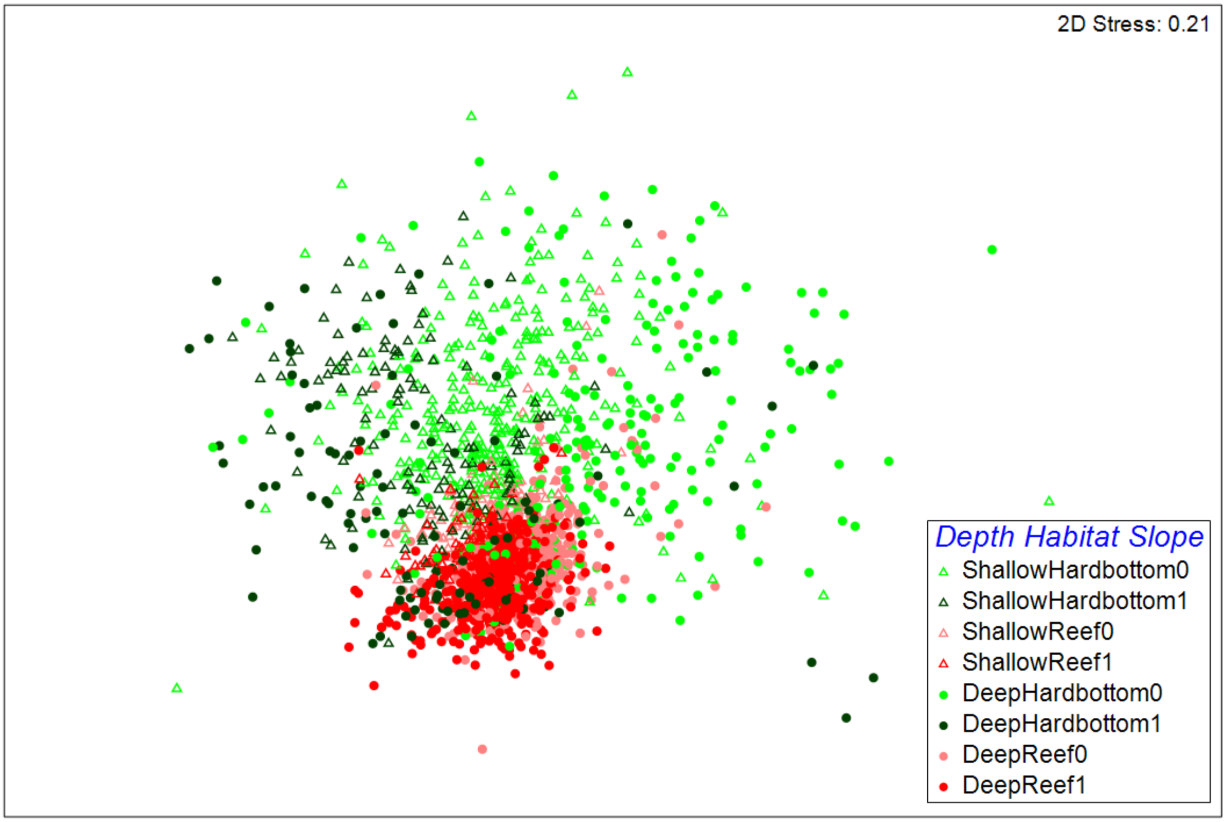

Figure 14. *MDS plot of all RVC SSUs (2012 – 2014) categorized by Depth, General Habitat and Slope. Some High Slope Deep Hardbottom sites clustered with the Deep Reef sites, but others were spread throughout.*

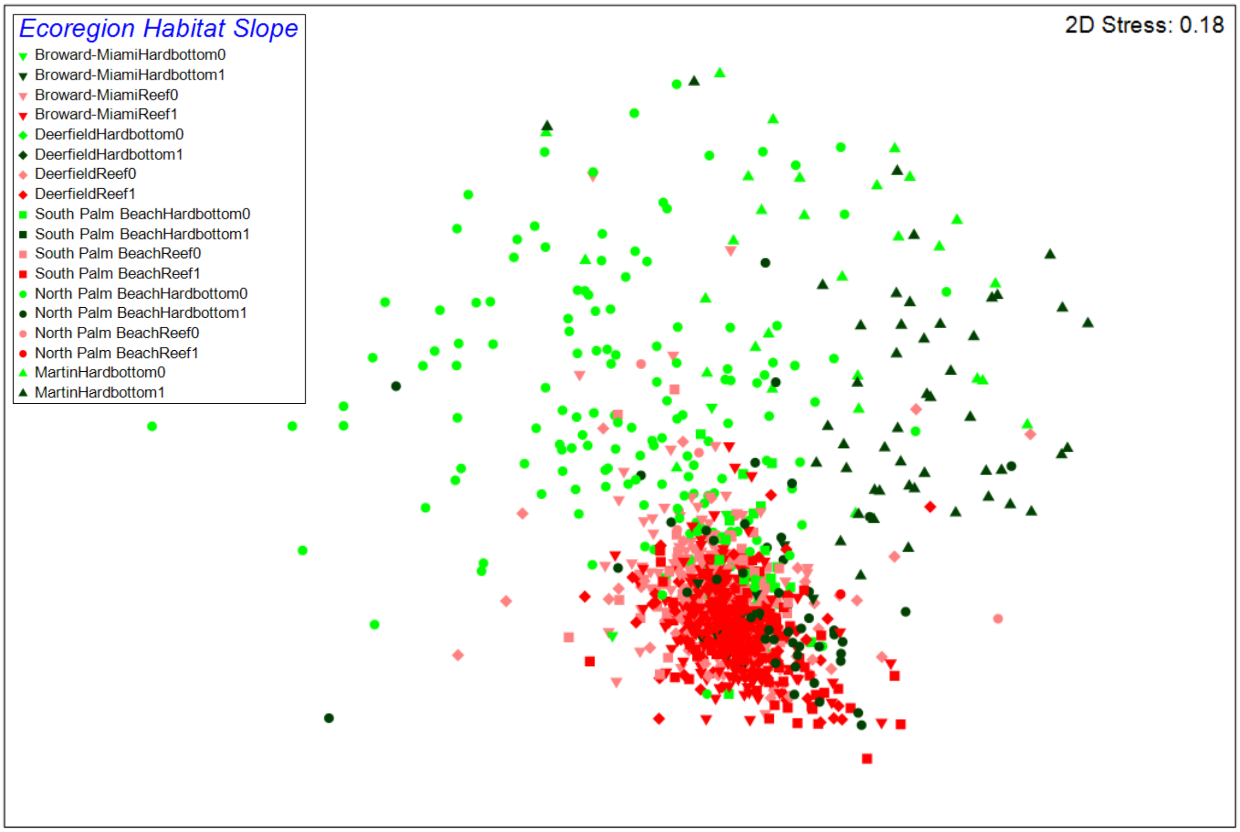

Figure 15. *MDS plot of all SSUs (2012 – 2014) on DEEP habitats only (APRD, CPDP, DPRC, LIRM, LIRO, PTCH, RGDP, SCRS, and SPGR) categorized by Coral Reef Ecosystem Region, General Habitat, and Slope.*

Table 5. *A similarity percentages analysis (SIMPER) of the transformed SSU species density data on Deep Habitats up to 50% cumulative percentage. The South Palm Beach Reef High Slope v. the North Palm Beach Hardbottom Low Slope (left) show very different abundances of reef fish species whereas the South Palm Beach Reef High Slope v. the North Palm Beach Hardbottom High Slope (right) are not as different.*

	South Palm Beach Reef High Slope	North Palm Beach HB High Slope				
Species	**Av.Abund**	**Av.Abund**	**Av.Diss**	**Diss/SD**	**Contrib%**	**Cum.%**
Bicolor Damselfish	5.23	6.91	3.55	1.31	5.38	5.38
Masked Goby	1.56	3.81	3.08	0.87	4.67	10.05
Bluehead Wrasse	4.04	5.43	2.82	1.21	4.28	14.33
Grunt spp.	0.46	2.03	1.97	0.52	2.99	17.32
Tomtate	0.02	2.76	1.78	0.47	2.7	20.02
Creole Wrasse	0.47	2.52	1.71	0.75	2.59	22.61
Yellowhead Wrasse	2.58	2.67	1.6	1.12	2.42	25.04
Blue Chromis	0.68	1.8	1.5	0.88	2.28	27.31
Porkfish	0.41	1.95	1.48	1.18	2.24	29.56
Redband Parrotfish	1.72	1.95	1.46	1.19	2.21	31.77
Sunshinefish	0.36	1.86	1.4	1.16	2.13	33.9
Greenblotch Parrotfish	0.49	1.74	1.37	1.18	2.07	35.97
Ocean Surgeonfish	2.12	1.52	1.32	1.08	2	37.97
Doctorfish	1.71	1.76	1.25	1.11	1.9	39.87
Slippery Dick	1.05	1.1	1.2	1.02	1.82	41.69
Purple Reeffish	0.13	1.69	1.15	0.86	1.75	43.44
Clown Wrasse	0.57	1.1	1.06	0.93	1.61	45.05
Striped Parrotfish	0.98	0.64	1	0.83	1.52	46.57
Blue Tang	0.96	1.18	0.96	1.16	1.46	48.03
White Grunt	0.5	1.11	0.94	0.9	1.42	49.45
Sharpnosed Pufferfish	1.78	1.25	0.93	1.01	1.41	50.86

Table 6. *A summary of the significant ANOSIM pairwise tests of the SSU's on Deep Habitats between the Eco-regions, general habitats, and slope. The R statistic indicates the strength of the difference where 1 is the strongest and 0 is weakest.*

Significant ANOSIM Pairwise Tests - Deep Habitats Only

Groups (EcoRegion, General Habitat, Slope)	R Statistic	Significance Level %
Broward-MiamiHardbottom0, Broward-MiamiHardbottom1	0.352	0.9
Broward-MiamiHardbottom0, DeerfieldReef1	0.288	2.7
Broward-MiamiHardbottom0, MartinHardbottom0	0.349	0.4
Broward-MiamiHardbottom0, MartinHardbottom1	0.538	0.1
Broward-MiamiHardbottom0, North Palm BeachHardbottom1	0.290	3.4
Broward-MiamiHardbottom0, South Palm BeachHardbottom0	0.353	2.5
Broward-MiamiHardbottom0, South Palm BeachReef1	0.421	0.4
Broward-MiamiHardbottom1, MartinHardbottom0	0.514	0.1
Broward-MiamiHardbottom1, MartinHardbottom1	0.544	0.1
Broward-MiamiHardbottom1, North Palm BeachReef0	0.583	0.1
Broward-MiamiHardbottom1, North Palm BeachReef1	0.575	3.8
Broward-MiamiHardbottom1, South Palm BeachHardbottom0	0.302	0.2
Broward-MiamiReef0, Broward-MiamiReef1	0.125	0.1
Broward-MiamiReef0, DeerfieldReef0	0.117	0.1
Broward-MiamiReef0, DeerfieldReef1	0.131	0.1
Broward-MiamiReef0, MartinHardbottom0	0.926	0.1
Broward-MiamiReef0, MartinHardbottom1	0.904	0.1
Broward-MiamiReef0, North Palm BeachHardbottom0	0.385	0.1
Broward-MiamiReef0, North Palm BeachHardbottom1	0.477	0.1
Broward-MiamiReef0, North Palm BeachReef0	0.487	0.1
Broward-MiamiReef0, South Palm BeachHardbottom0	0.269	0.2
Broward-MiamiReef0, South Palm BeachReef0	0.167	0.1
Broward-MiamiReef0, South Palm BeachReef1	0.294	0.1
Broward-MiamiReef1, Broward-MiamiHardbottom0	0.380	0.5
Broward-MiamiReef1, DeerfieldReef0	0.225	0.1
Broward-MiamiReef1, DeerfieldReef1	0.114	0.1
Broward-MiamiReef1, MartinHardbottom0	0.981	0.1
Broward-MiamiReef1, MartinHardbottom1	0.966	0.1
Broward-MiamiReef1, North Palm BeachHardbottom0	0.605	0.1
Broward-MiamiReef1, North Palm BeachHardbottom1	0.516	0.1
Broward-MiamiReef1, North Palm BeachReef0	0.676	0.1
Broward-MiamiReef1, North Palm BeachReef1	0.418	4.6
Broward-MiamiReef1, South Palm BeachHardbottom0	0.444	0.1
Broward-MiamiReef1, South Palm BeachReef0	0.294	0.1
Broward-MiamiReef1, South Palm BeachReef1	0.241	0.1
DeerfieldHardbottom0, MartinHardbottom0	0.536	3.3
DeerfieldReef0, DeerfieldReef1	0.043	0.1
DeerfieldReef0, MartinHardbottom0	0.873	0.1
DeerfieldReef0, MartinHardbottom1	0.801	0.1
DeerfieldReef0, North Palm BeachHardbottom0	0.234	0.1
DeerfieldReef0, North Palm BeachHardbottom1	0.262	0.1
DeerfieldReef0, North Palm BeachReef0	0.394	0.7
DeerfieldReef0, South Palm BeachHardbottom0	0.185	1.5
DeerfieldReef0, South Palm BeachReef0	0.042	4.3
DeerfieldReef0, South Palm BeachReef1	0.130	0.1
DeerfieldReef1, MartinHardbottom0	0.949	0.1
DeerfieldReef1, MartinHardbottom1	0.898	0.1
DeerfieldReef1, North Palm BeachHardbottom0	0.323	0.1
DeerfieldReef1, North Palm BeachHardbottom1	0.327	0.1
DeerfieldReef1, North Palm BeachReef0	0.590	0.1
DeerfieldReef1, South Palm BeachHardbottom0	0.343	0.1
DeerfieldReef1, South Palm BeachReef0	0.131	0.1
DeerfieldReef1, South Palm BeachReef1	0.081	0.1
MartinHardbottom0, DeerfieldHardbottom1	0.510	0.2
MartinHardbottom0, MartinHardbottom1	0.342	0.1
MartinHardbottom0, North Palm BeachReef0	0.215	1.3
MartinHardbottom1, DeerfieldHardbottom1	0.574	1.5
MartinHardbottom1, North Palm BeachReef0	0.523	0.1
North Palm BeachHardbottom0, MartinHardbottom0	0.397	0.1
North Palm BeachHardbottom0, MartinHardbottom1	0.451	0.1
North Palm BeachHardbottom0, North Palm BeachHardbottom1	0.160	0.1
North Palm BeachHardbottom1, MartinHardbottom0	0.674	0.1
North Palm BeachHardbottom1, MartinHardbottom1	0.549	0.1
North Palm BeachHardbottom1, North Palm BeachReef0	0.264	3.8
South Palm BeachHardbottom0, MartinHardbottom0	0.464	0.1
South Palm BeachHardbottom0, MartinHardbottom1	0.550	0.1
South Palm BeachHardbottom0, North Palm BeachHardbottom1	0.199	0.1
South Palm BeachHardbottom0, North Palm BeachReef0	0.298	0.5
South Palm BeachHardbottom0, South Palm BeachReef0	0.127	2.2
South Palm BeachHardbottom0, South Palm BeachReef1	0.367	0.1
South Palm BeachReef0, MartinHardbottom0	0.853	0.1
South Palm BeachReef0, MartinHardbottom1	0.793	0.1
South Palm BeachReef0, North Palm BeachHardbottom0	0.099	0.6
South Palm BeachReef0, North Palm BeachHardbottom1	0.318	0.1
South Palm BeachReef0, North Palm BeachReef0	0.362	0.2
South Palm BeachReef0, South Palm BeachReef1	0.208	0.1
South Palm BeachReef1, MartinHardbottom0	0.937	0.1
South Palm BeachReef1, MartinHardbottom1	0.873	0.1
South Palm BeachReef1, North Palm BeachHardbottom0	0.318	0.1
South Palm BeachReef1, North Palm BeachHardbottom1	0.197	0.1
South Palm BeachReef1, North Palm BeachReef0	0.655	0.1

(continued from page 29) …level <5%. Along with significance the R statistic must be considered. It indicates the strength of the difference where 1 is the strongest and 0 is weakest. The strongest differences in the ANOSIM were between Broward-Miami High Slope Reef and Martin Low Slope Hardbottom. Several other similar habitat combinations exhibited very strong differences. Interestingly North Palm Beach High Slope Hardbottom SSUs were quite different from the Martin High and Low Slope Hardbottom. These analyses support that general reef type (Reef v. Hardbottom), slope, and the Ecosystem region affects the fish community composition and density on the deep habitats in the SEFCRI region. In particular the Martin High and Low Slope Hardbottom and the North Palm Beach Low Slope Hardbottom fish communities are distinctly different from habitats in the southern regions, i.e. South Palm Beach, Deerfield, and Broward-Miami, that are more similar to each other.

The fish communities in shallow habitats (RGSH, CPSH, and LIRI) also showed statistically significant patterns in the MDS (Figure 16). Both the High and Low Slope Reef SSUs were a more compact cluster in the MDS indicating that they were more similar to each other. The Hardbottom SSU plots had a wider spread indicating higher variability, but separation by region was evident. The Low Slope Broward-Miami Hardbottom SSUs were the most variable as indicated by the spread throughout the MDS. The High Slope Broward-Miami Hardbottom SSUs were more tightly clustered near the Reef sites indicating that those communities were more similar to each other. The Martin Hardbottom SSU plots were mostly clustered together away from other sites, but a few sites from other regions comingled with the Martin Hardbottom plots in the MDS. ANOSIM showed significant differences between 40 pairwise tests (Table 7). The strongest community differences were between Broward-Miami Reef SSUs and all Hardbottom SSUs expect Broward-Miami High Slope Hardbottom (R = 0.27 – 0.98). The High Slope Broward-Miami Hardbottom community was also significantly different from other Hardbottom communities (R = 0.30 – 0.54). The Low Slope Broward-Miami Hardbottom was not as different from the other Hardbottom habitats although differences were significant, the strength was much lower (R = 0.29 – 0.53).

A SIMPER analysis between the Broward-Miami High Slope Reef sites and the Martin High Slope Hardbottom sites exemplified the community differences in shallow habitats along the coast (Table 8). Some of the notable species contributing to the community differences were Bicolor Damselfish (*Stegastes partitus*), Bluehead Wrasse (*Thalassoma bifasciatum*), Masked/Glass Goby (*Coryphopterus personatus/hyalinus*), Tomtate (*Haemulon aurolineatum*), Redband Parrotfish (*Sparisoma aurofrenatum*), Porkfish (*Anisotremus virginicus*), Yellowhead Wrasse (*Halichoeres garnoti*), French Grunt (*Haemulon flavolineatum*), and Spottail Pinfish (*Diplodus holbrookii*). *Stegastes partitus*, *Thalassoma bifasciatum*, *Coryphopterus personatus*, *Sparisoma aurofrenatum*, *Halichoeres garnoti*, and *Haemulon flavolineatum* were found in much higher abundances at the Broward-Miami Reef SSUs whereas *Haemulon aurolineatum, Anisotremus virginicus, and Diplodus holbrookii* were found in higher abundances at Martin sites. The known ranges of these species are also quite different (Figure 17). Examples of known ranges were obtained via Aquamaps (www.aquamaps.org) using data from Kaschner et al. (2013) for some of the species driving the differences between the Broward-Miami High Slope Reef and Martin High Slope Hardbottom shallow fish communities support the SIMPER analyses. The species found in higher abundances at Martin sites (left) have ranges that extend much farther north indicating they live in a broader range of water temperatures. The ranges of the species found in much higher abundances further south (right) diminish rapidly to the north indicating they are less tolerant of colder conditions (i.e. more tropical).

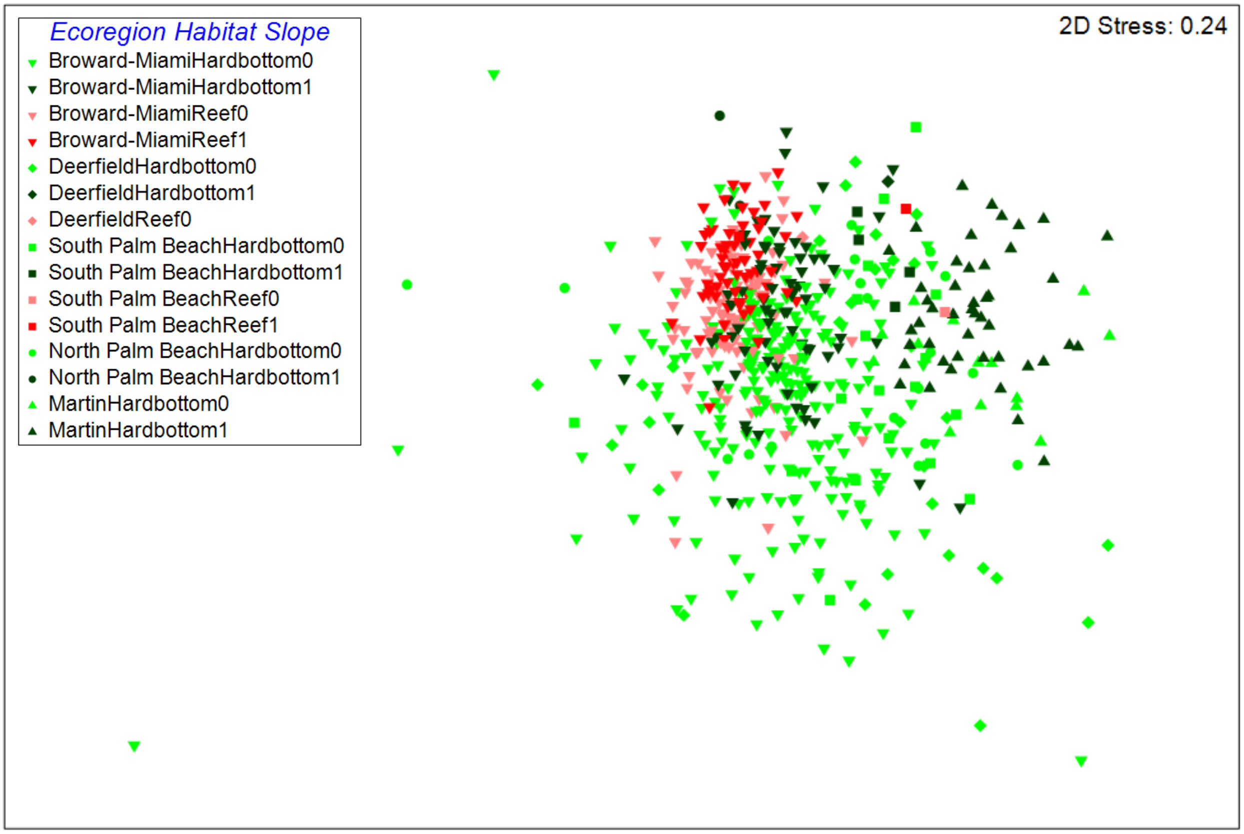

Figure 16. *MDS plot of all SSUs (2012 – 2014) on SHALLOW habitats only (*RGSH, CPSH, and LIRI*) categorized by Coral Reef Ecosystem Region, General Habitat, and Slope.*

Table 7. *A summary of the significant ANOSIM pairwise tests of the SSU's on Shallow Habitats between the Eco-regions, general habitats, and slope. The R statistic indicates the strength of the difference where 1 is the strongest and 0 is weakest.*

Significant ANOSIM Pairwise Tests - Shallow Habitats Only

Groups (EcoRegion, General Habitat, Slope)	R Statistic	Significance Level %
Broward-MiamiHardbottom0, Broward-MiamiReef1	0.101	0.9
Broward-MiamiHardbottom0, DeerfieldHardbottom0	0.425	0.1
Broward-MiamiHardbottom0, MartinHardbottom0	0.429	0.1
Broward-MiamiHardbottom0, MartinHardbottom1	0.495	0.1
Broward-MiamiHardbottom0, North Palm BeachHardbottom0	0.336	0.1
Broward-MiamiHardbottom0, North Palm BeachHardbottom1	0.527	1.9
Broward-MiamiHardbottom0, South Palm BeachHardbottom0	0.287	0.1
Broward-MiamiHardbottom1, Broward-MiamiReef1	0.181	0.1
Broward-MiamiHardbottom1, DeerfieldHardbottom0	0.575	0.1
Broward-MiamiHardbottom1, DeerfieldHardbottom1	0.715	4.1
Broward-MiamiHardbottom1, MartinHardbottom0	0.693	0.1
Broward-MiamiHardbottom1, MartinHardbottom1	0.722	0.1
Broward-MiamiHardbottom1, North Palm BeachHardbottom0	0.546	0.1
Broward-MiamiHardbottom1, North Palm BeachHardbottom1	0.593	1.1
Broward-MiamiHardbottom1, South Palm BeachHardbottom0	0.598	0.1
Broward-MiamiHardbottom1, South Palm BeachHardbottom1	0.375	1.8
Broward-MiamiHardbottom1, South Palm BeachReef0	0.734	2.7
Broward-MiamiReef0, Broward-MiamiHardbottom1	0.183	0.1
Broward-MiamiReef0, Broward-MiamiReef1	0.061	0.7
Broward-MiamiReef0, DeerfieldHardbottom0	0.774	0.1
Broward-MiamiReef0, DeerfieldHardbottom1	0.919	1.1
Broward-MiamiReef0, MartinHardbottom0	0.888	0.1
Broward-MiamiReef0, MartinHardbottom1	0.915	0.1
Broward-MiamiReef0, North Palm BeachHardbottom0	0.742	0.1
Broward-MiamiReef0, North Palm BeachHardbottom1	0.673	0.7
Broward-MiamiReef0, South Palm BeachHardbottom0	0.794	0.1
Broward-MiamiReef0, South Palm BeachHardbottom1	0.769	0.1
Broward-MiamiReef0, South Palm BeachReef0	0.857	3.3
Broward-MiamiReef0, South Palm BeachReef1	0.364	4.6

Groups (EcoRegion, General Habitat, Slope)	R Statistic	Significance Level %
Broward-MiamiReef1, DeerfieldHardbottom0	0.772	0.1
Broward-MiamiReef1, DeerfieldHardbottom1	0.995	1.6
Broward-MiamiReef1, MartinHardbottom0	0.967	0.1
Broward-MiamiReef1, MartinHardbottom1	0.946	0.1
Broward-MiamiReef1, North Palm BeachHardbottom0	0.857	0.1
Broward-MiamiReef1, North Palm BeachHardbottom1	0.746	0.3
Broward-MiamiReef1, South Palm BeachHardbottom0	0.924	0.1
Broward-MiamiReef1, South Palm BeachHardbottom1	0.908	0.1
Broward-MiamiReef1, South Palm BeachReef0	0.989	1.6
Broward-MiamiReef1, South Palm BeachReef1	0.429	1.7
DeerfieldHardbottom0, MartinHardbottom0	0.159	1
DeerfieldHardbottom0, MartinHardbottom1	0.591	0.1
DeerfieldHardbottom0, North Palm BeachHardbottom0	0.086	4.3
DeerfieldReef0, MartinHardbottom1	0.666	2.1
MartinHardbottom0, North Palm BeachHardbottom1	0.828	0.8
MartinHardbottom0, South Palm BeachReef1	0.593	0.1
MartinHardbottom1, DeerfieldHardbottom1	0.892	2.1
MartinHardbottom1, MartinHardbottom0	0.266	0.1
MartinHardbottom1, North Palm BeachHardbottom1	0.954	0.1
MartinHardbottom1, South Palm BeachHardbottom1	0.471	0.3
MartinHardbottom1, South Palm BeachReef0	0.727	2.1
MartinHardbottom1, South Palm BeachReef1	0.823	0.1
North Palm BeachHardbottom0, MartinHardbottom0	0.130	1
North Palm BeachHardbottom0, MartinHardbottom1	0.535	0.1
South Palm BeachHardbottom0, MartinHardbottom0	0.227	0.1
South Palm BeachHardbottom0, MartinHardbottom1	0.616	0.1
South Palm BeachHardbottom0, North Palm BeachHardbottom1	0.573	2.1
South Palm BeachHardbottom0, South Palm BeachReef1	0.371	1.7

Table 8. *A similarity percentages analysis (SIMPER) of the transformed SSU species density data on Shallow Habitats up to 50% cumulative percentage. The Broward-Miami High Slope Reef v. Martin High Slope Hardbottom show very different abundances of reef fish species contributing to the community differences.*

	Broward-Miami Reef High Slope	**Martin HB High Slope**				
Species Code	**Av.Abund**	**Av.Abund**	**Av.Diss**	**Diss/SD**	**Contrib%**	**Cum.%**
Bicolor Damselfish	5.3	0.17	5.54	2.49	6.83	6.83
Bluehead Wrasse	5.04	0.7	4.75	1.99	5.85	12.67
Masked Goby	3.94	0.2	3.79	1.01	4.66	17.33
Tomtate	0.9	3.33	3.59	0.94	4.41	21.75
Redband Parrotfish	2.69	0.02	2.96	2.58	3.65	25.39
Grunt spp.	0.34	2.75	2.83	0.71	3.49	28.88
Porkfish	0.79	2.69	2.34	1.51	2.88	31.76
Yellowhead Wrasse	2.13	0	2.26	2.17	2.78	34.55
French Grunt	2.32	0.59	2.18	0.98	2.68	37.23
Ocean Surgeonfish	2.37	0.81	2.05	1.45	2.52	39.75
Clown Wrasse	1.71	0.05	1.75	1.18	2.15	41.91
Striped Parrotfish	1.66	0.03	1.72	1.34	2.12	44.03
Spottail Pinfish	0	1.48	1.68	1.31	2.07	46.09
Blue Tang	1.64	0.14	1.64	1.49	2.02	48.11
Doctorfish	1.16	1.57	1.49	1.27	1.84	49.95
White Grunt	1.23	1.22	1.45	1.12	1.79	51.74

Figure 17. *Examples of known ranges for some of the species driving the differences between the shallow Broward-Miami High Slope Reef and Martin High Slope Hardbottom fish communities (Kaschner et al., 2013). The species on the left have ranges that extend much farther north indicating they live in a broader range of water temperatures whereas the species on the right diminish rapidly to the north indicating they are less tolerant of colder conditions (i.e. more tropical).*

Table 9. *A similarity percentages analysis (SIMPER) of the transformed SSU species density data on Deep Habitats up to 50% cumulative percentage. The Broward-Miami High Slope Reef v. the North Palm Beach Low Slope Hardbottom show very different abundances of reef fish species contributing to the community differences.*

Species Code	Broward-Miami Reef High Slope Av.Abund	North Palm Beach HB Low Slope Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Bicolor Damselfish	6.38	1.84	6.38	1.73	8.29	8.29
Bluehead Wrasse	4.66	1.67	4.7	1.48	6.11	14.4
Masked Goby	3.41	0.32	4.22	0.85	5.48	19.89
Redband Parrotfish	2.5	0.31	2.94	1.65	3.83	23.72
Yellowhead Wrasse	2.76	1.06	2.78	1.38	3.62	27.33
Ocean Surgeonfish	2.08	0.83	2.18	1.27	2.84	30.17
Doctorfish	1.87	0.97	2.07	1.11	2.69	32.86
Blue Chromis	1.54	0.04	1.83	0.9	2.38	35.24
Slippery Dick	0.5	1.39	1.77	1.07	2.3	37.54
Greenblotch Parrotfish	0.89	1.19	1.61	1.1	2.09	39.64
Sharpnose Pufferfish	1.76	0.79	1.59	1.35	2.07	41.71
Reef Butterflyfish	1.38	0.27	1.58	1.64	2.05	43.75
Blue Tang	1.17	0.32	1.45	1.23	1.89	45.64
Green Razorfish	0.04	1.02	1.4	0.78	1.81	47.45
Sunshinefish	0.99	0.35	1.39	0.66	1.81	49.26

Figure 18. *Examples of known ranges for some of the species driving the differences between the deep Broward-Miami High Slope Reef and North Palm Beach Low Slope Hardbottom fish communities (Kaschner et al., 2013). These species have ranges that extend much farther north indicating they live in a broader range of water temperatures compared to the species in Figure 17 on the right that diminish rapidly to the north indicating they are less tolerant of colder conditions (i.e. more tropical).*

The significant differences between fish communities in the northern regions (Martin and North Palm Beach) versus those found further south coincide with differences in benthic communities of Walker and Gilliam (2013). They found that benthic communities were explained by differences in temperature regimes along the southeast Florida coast. The northern communities were dominated by cold-tolerant coral species and the number of tropical species was substantially diminished. Analyses of bottom temperature differences along the reef tract showed significant cold-water upwelling occurs more frequently and intensely in the northern regions north of an area referred to as the Bahamas Fracture Zone (Walker et al., *in prep*); a geological feature that coincides with the end of historical outer reef growth and where the Florida Current diverges from the coast. Interestingly the region of highest species richness was South Palm Beach (Figure 6) which is just south of the Bahamas Fracture Zone. This could be the area of highest overlap between the tropical and more temperate fish communities. More investigation is needed on the spatial extent of reef fish species to understand what is driving this result and determine if it is due to an overlap of temperate and tropical species or if there is another factor causing higher richness values in this subregion.

4.1.4. Exploited Species

Most exploited species showed a cosmopolitan but unequal distribution across all the strata, and varying degrees of interannual variation. Of the eight species, Gray Triggerfish (*Balistes capriscus*), White and Bluestriped Grunts (*Haemulon plumierii* and *H. sciurus*) and Yellowtail Snapper (*Ocyurus chrysurus*) exhibited higher densities than the other species (Figure 19). Red Grouper (*Epinephelus morio*) exhibited the lowest densities, which decreased slightly each year. When the data from all three years are combined and split out by pre-exploited and exploited phase, it is clear that for many exploited species (*B. capriscus*, *E. morio*, *L. maximus*, *L. analis*, *L. griseus*, and *O. chrysurus*) the pre-exploited phase is largely responsible for driving the observed trends in mean density (Figures 21, 26, 41, 46, 51, 56). This is further confirmed by partitioning of the data into discrete size classes (by 5 cm increments) and plotting the total number of observations from each size class (Figures 24, 29, 44, 49, 54, 59). In contrast, with White and Bluestriped Grunts it appears that both pre-exploited and exploited phase life-stages are responsible for driving the observed trends (Figures 31, 34, 36, 39). It is noteworthy that the pre-exploited size ranges for all the exploited species have low numbers in newly settled and early juvenile size ranges. This likely indicates that either nursery areas were not sampled or the point-count methodology was not effective for fishes in this size range, or both.

During the 3 year survey period, the following species were encountered, but in very low numbers (≤50 total individuals) (Table 10): Tarpon (*Megalops atlanticus*); Common Snook (*Centropomus undecimalis*); Groupers - Coney (*Cephalopholis fulva*), Rock Hind (*Epinephelus adscensionis*), Red Hind (*E. guttatus*), Goliath (*E. itajara*), Black (*Mycteroperca bonaci*), Gag (*M. microlepis*), and Scamp (*M. phenax*); Cobia (*Rachycentron canadum*); Greater Amberjack (*Seriola dumerili*); Snappers - Blackfin (*Lutjanus buccanella*), Red (*L. campechanus*), Cubera (*L. cyanopterus*), Dog (*L. jocu*), and Vermillion (*Rhomboplites aurorubens*); and Great Barracuda (*Sphyraena barracuda*). None (zero) of the following species were recorded: Groupers - Speckled Hind (*E. drummondhayi*), Warsaw (*E. nigritus*), Snowy (*E. niveatus*), Nassau (*E. striatus*), Yellowmouth (*M. interstitialis*), Tiger (*M. tigris*), Yellowfin (*M. venenosa*), Yellowedge (*Hyporthodus flavolimbatus*), and Misty (*H. mystacinus*); Snappers - Black (*Apsilus* *dentatus*), Queen (*Etelis oculatus*), Silk (*L. vivanus*), and Wenchman (*Pristipomoides macropthalmus*).

Table 10. *The total number of fish (from mean SSU density totals), total number of legal/exploited phase individuals, the percentage of legal/exploited phase individuals, average Density ($\bar{D}$) (fish/SSU), average Percent Occurrence ($\bar{P}$) per SSU, the mean, minimum, and maximum observed sizes, and the minimum legal/exploited sizes. This list includes the 8 target species and several other species of commercial and recreational importance. Species are listed in phylogenetic order and sizes are listed in centimeters unless otherwise noted.*

Species	Total	Expl.	%	$\bar{D}$	$\bar{P}$	Mean (Min, Max)	Min. Legal/Expl. Size
Tarpon	5	n/a	n/a	0.004	0.4	135 (100, 200)	catch-and-release
Lionfish	273	n/a	n/a	0.1	11.3	20 (3, 43)	unregulated
Common Snook	31	24	76.2	0.003	0.01	75 (65, 88)	71.1 (28")
Black Seabass	332	4	1.1	0.005	0.5	19 (7, 41)	33.0 (13")
Coney	43	n/a	n/a	0.02	2.0	17 (6, 35)	unregulated
Graysby	416	n/a	n/a	0.2	20.0	16 (3, 45)	unregulated
Red Hind	17	n/a	n/a	0.01	1.0	20 (9, 36)	unregulated
Rock Hind	22	n/a	n/a	0.008	0.8	21 (7, 40)	unregulated
Goliath Grouper	27	n/a	n/a	0.002	0.2	159 (90, 220)	harvest prohibited
Red Grouper	113	9	7.9	0.06	8.4	35 (12, 61)	50.8 (20")
Black Grouper	16	0	0.0	0.007	1.2	40(7, 60)	61.0 (24")
Gag Grouper	12	2	12.5	0.002	0.3	37 (17, 90)	61.0 (24")
Scamp Grouper	27	1	1.9	0.005	0.8	29 (14, 55)	50.8 (20")
Cobia	3	2	80.0	0.001	0.3	103 (80, 125)	83.8 (33")
Greater Amberjack	43	0	0.0	0.009	0.3	33 (13, 50)	71.1 (28")
Blackfin Snapper	1	0	0.0	0.00005	0.01	6.0 (-, -)	30.5 (12")
Cubera Snapper	3	2	80.0	0.0002	0.02	41 (20, 50)	30.5 (12")
Dog Snapper	8	7	86.7	0.002	0.3	36 (27, 51)	30.5 (12")
Gray Snapper	954	289	30.3	0.4	9.4	22 (4, 46)	25.4 (10")
Lane Snapper	1969	994	50.5	0.6	6.3	17 (2, 38)	20.3 (8")
Mahogany Snapper	52	0	0.0	0.03	0.9	18 (6, 29)	30.5 (12")
Mutton Snapper	354	82	23.0	0.2	26.2	34 (13, 71)	40.6 (16")
Red Snapper	1	0	0.0	0.00005	0.01	40 (-, -)	50.8 (20")
Schoolmaster Snapper	119	17	14.3	0.07	0.6	23 (7, 34)	25.4 (10")
Vermillion Snapper	20	3	12.5	0.005	0.4	19 (3, 33)	30.5 (12")
Yellowtail Snapper	1763	359	20.4	1.0	26.3	31 (2, 45)	30.5 (12")
White Grunt	3047	1080	35.5	1.6	39.8	17 (2, 45)	20.3 (8")
Bluestriped Grunt	2041	667	32.7	1.3	14.8	19 (2, 36)	20.3 (8")
Hogfish	655	144	22.0	0.3	22.6	24 (6, 60)	30.5 (12")
Great Barracuda	50	n/a	n/a	0.02	1.4	106 (35, 200)	unregulated
Cero Mackerel	71	n/a	n/a	0.02	2.0	41 (25, 80)	unregulated
Gray Triggerfish	1700	16	0.9	1.2	40.9	21 (4, 46)	35.6 (14")

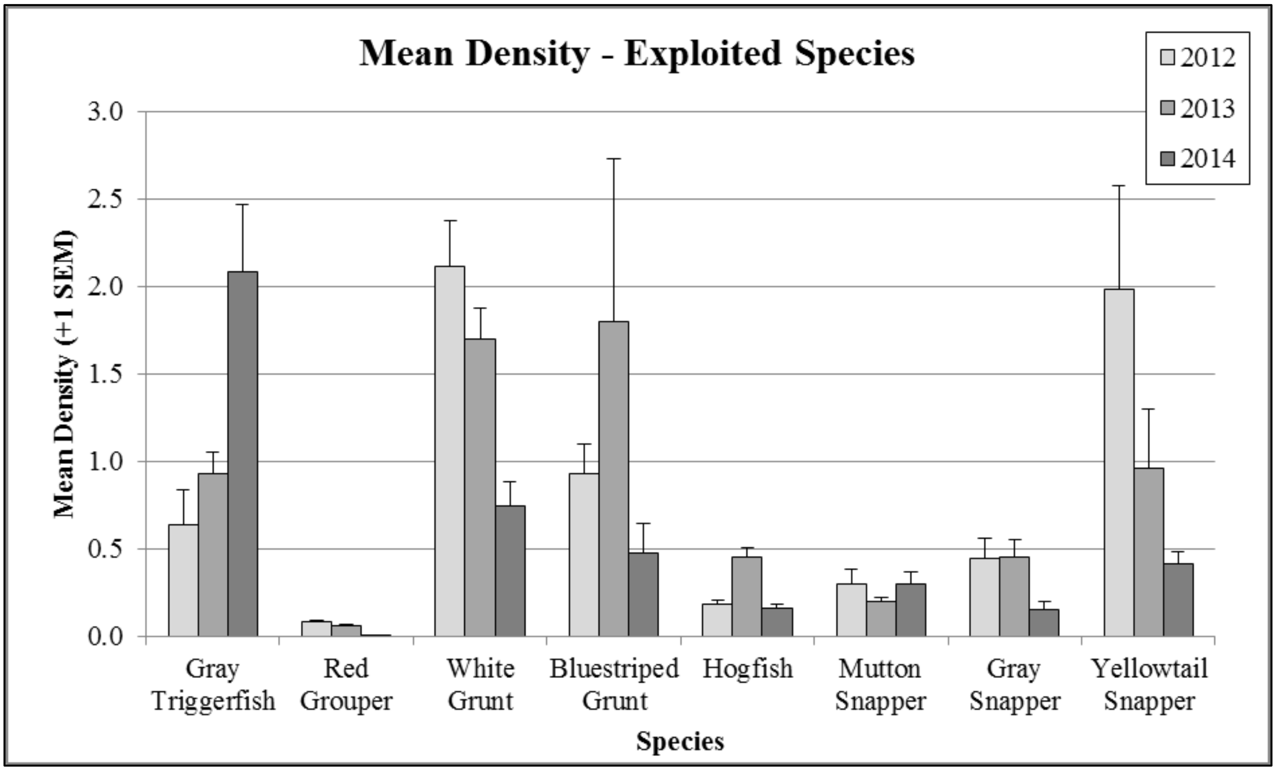

Figure 19. *Mean Density for exploited species, by year.*

4.1.5. Exploited Species: Gray Triggerfish

Gray Triggerfish (*Balistes capriscus*) was the 13th most frequently encountered and 22nd most abundant species, with a mean percent occurrence ($\bar{P}$) of 40.5 and mean SSU density ($\bar{D}$) of 1.22 fishes/SSU (Appendix 6). Percent occurrence of this species in the FL Keys and Dry Tortugas was below 10%. Comparison of Gray Triggerfish densities by strata (Figure 20) illustrates similarities among years for all strata, with the exception of 2014 which had peaks in: shallow patch-reef (PTSH), linear reef outer (OFFR), deep ridge complex (DPRC), and ridge deep (RGDP). In general, the low relief sites had overall higher Gray Triggerfish densities. Comparison of the different lifestages to low and high relief habitats (Figures 21, 22, and 23) shows some increased association of both pre-exploited and exploited phase triggerfish for low-relief, suggesting that the presence of this species may not be as dependent upon vertical relief and structure as it is for many other species. However, the general absence of the larger size classes must also be taken into consideration (Figure 24); the average size of exploited-phase individuals was 37 cm, and 1.4% of the total number of Gray Triggerfish recorded qualified as exploited-phase (≥35 cm). In addition, a gradual trend of increasing size with increasing depth was noted, with the largest individuals occurring in the DPRC and RGDP strata and in the North Palm Beach and Martin subregions (Appendix 8). Greatest density was observed in the South Palm Beach subregion, and from the 15-20m depth range.

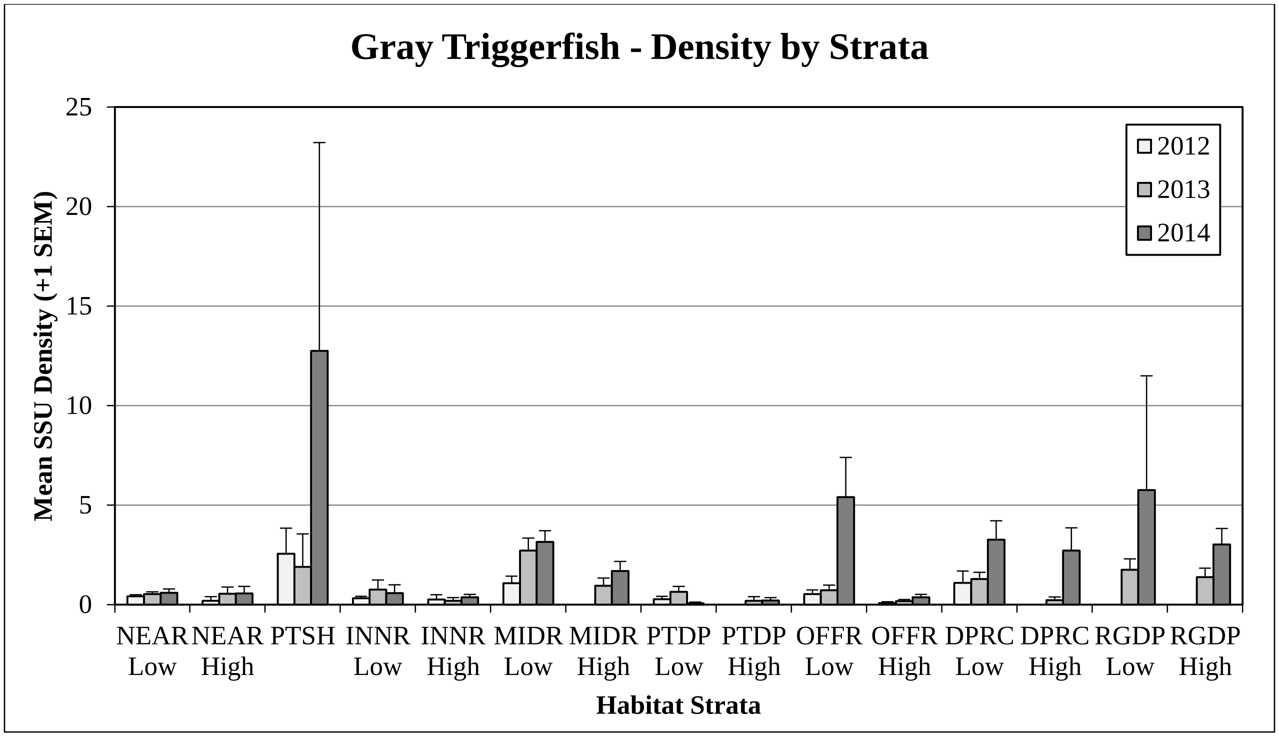

Figure 20. *Gray Triggerfish (*Balistes capriscus*) total mean density per strata; yearly comparison.*

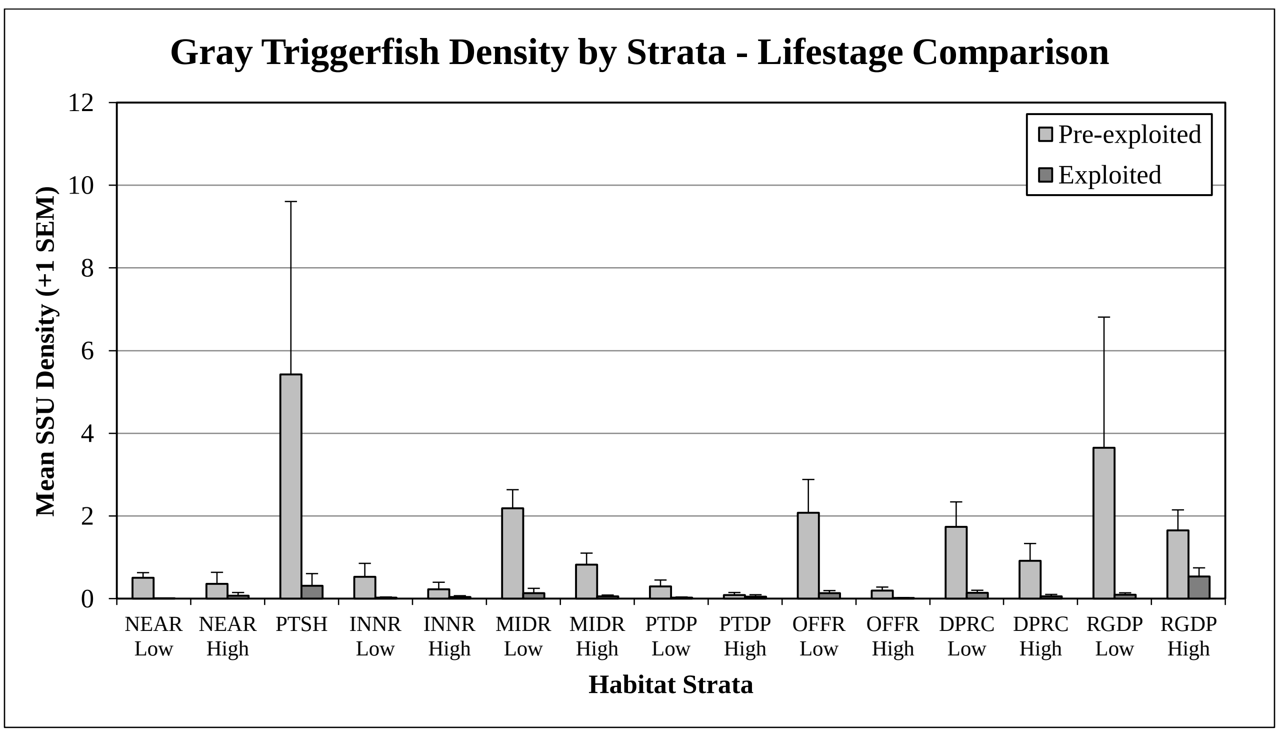

Figure 21. *Gray Triggerfish (*Balistes capriscus*) total mean density by strata; pre-exploited and exploited lifestage comparison; 2012-2014 combined.*

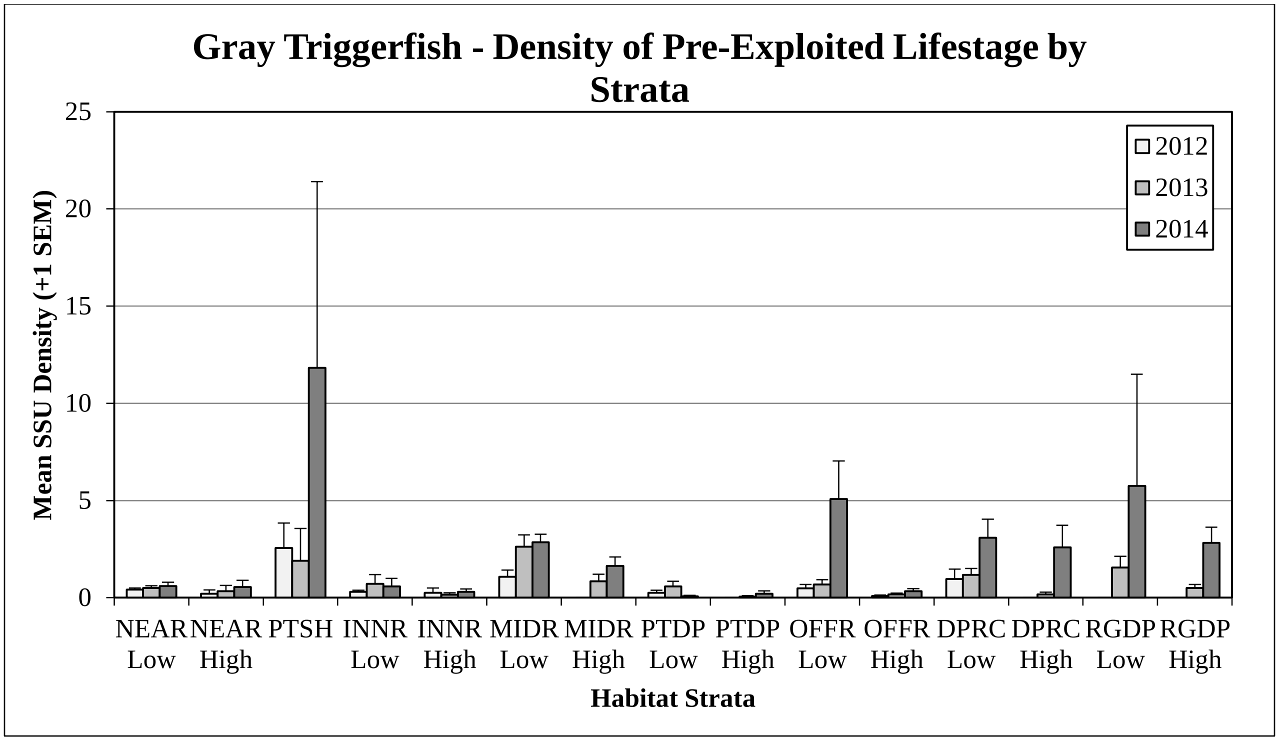

Figure 22. *Gray Triggerfish (*Balistes capriscus*) total mean density per habitat strata; pre-exploited lifestage comparison only.*

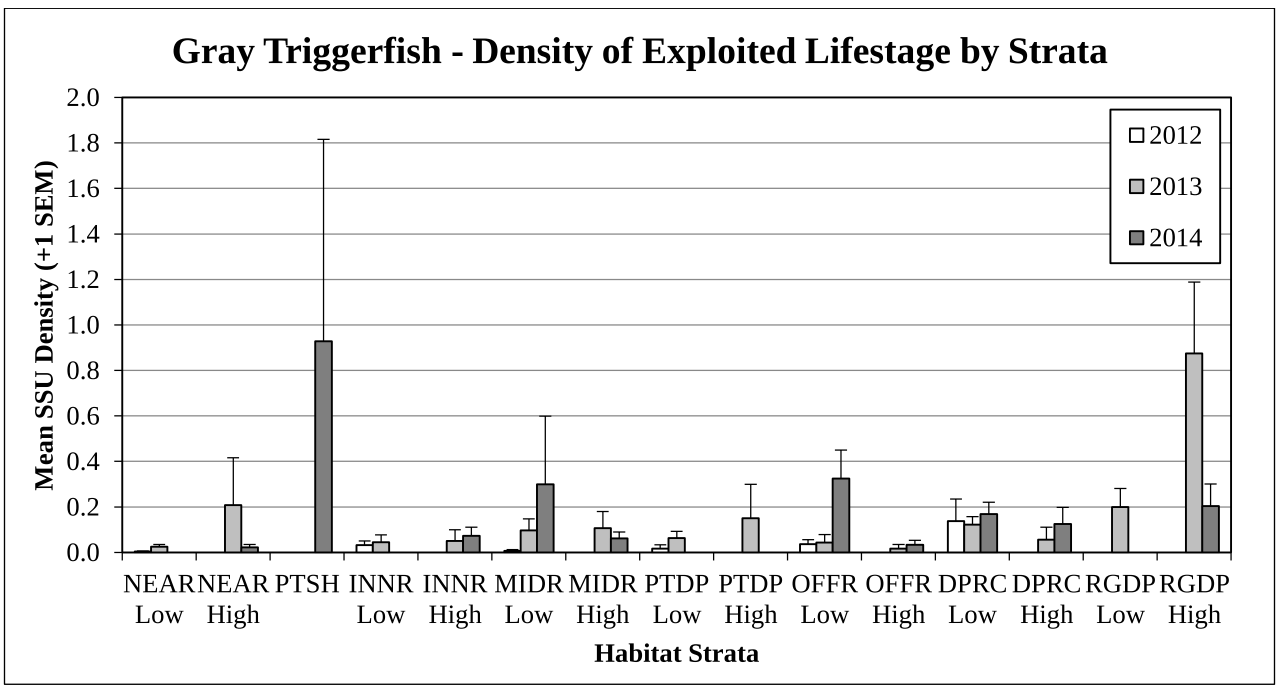

Figure 23. *Gray Triggerfish (*Balistes capriscus*) total mean density per habitat strata; exploited lifestage comparison only.*

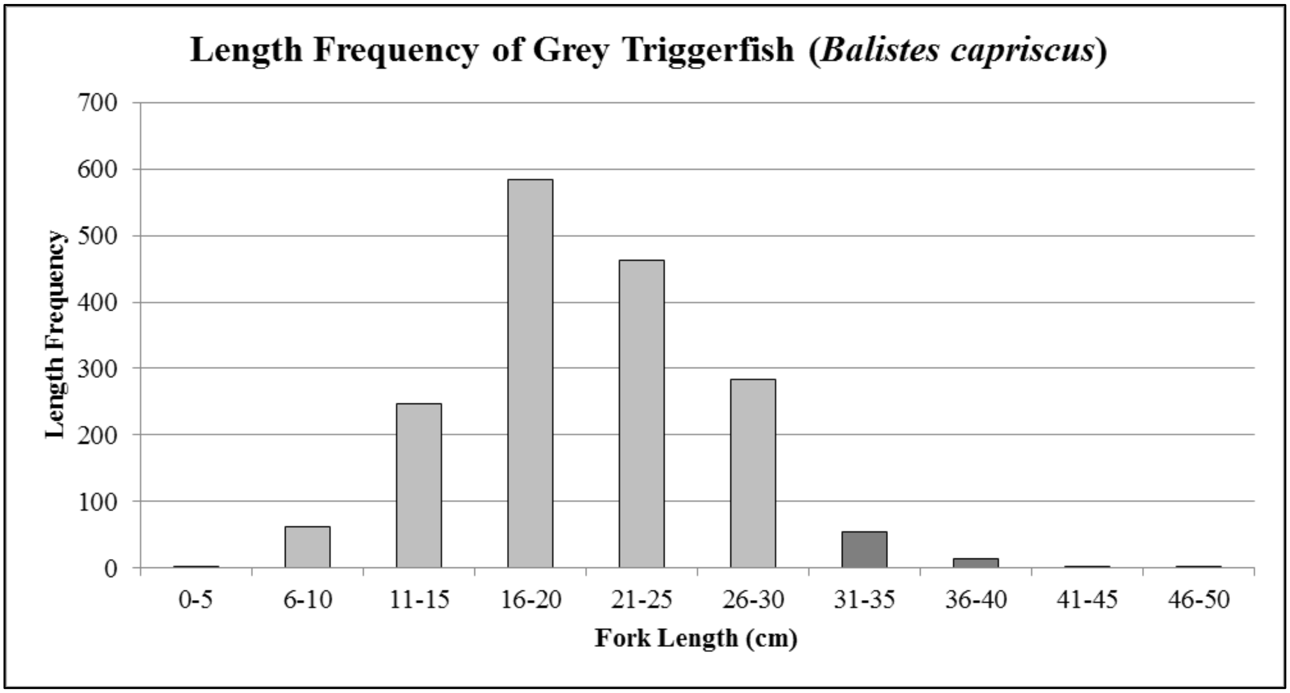

Figure 24. *Length frequency of Gray Triggerfish (*Balistes capriscus*) by size class, all years combined. Darker gray indicates exploited size classes; legal minimum size of harvest for this species changed from 12 in. (30.5 cm) to 14 in. (35.6 cm) in April 2015.*

4.1.6. Exploited Species: Red Grouper

Red Grouper (*Epinephelus morio*) was the 81st most frequently observed species, with an average percent occurrence ($\bar{P}$) of 7.2 and average density ($\bar{D}$) of 0.04 fishes/SSU (Appendix 6). Comparatively, the data suggest that southeast FL has far fewer Red Groupers than the FL Keys ($\bar{P}$=20.4, $\bar{D}$=0.16) and Dry Tortugas ($\bar{P}$=62.2, $\bar{D}$=0.62). Examination of Red Grouper densities by habitat strata (Figure 25) reveals a considerable amount of inter-annual variation, although in general there were greater numbers of this species seen during the 2012 surveys. Although the sample size is small (out of 3,320 counts only 257 Red Groupers were encountered), when low-high slope pairings within strata are compared, the data suggests that there may be a preference for low relief habitats for most strata; especially when the pre-exploited size class is examined (Figure 27). The average size of exploited-phase individuals was 54.6 cm, and 8.3% of the total number observed qualified as exploited-phase (≥50 cm) (Figure 29). Red Groupers of legal size were only encountered on the ridge-shallow (NEAR), linear reef-inner (INNR), linear reef-middle (MIDR), linear reef-outer (OFFR), and deep ridge complex (DPRC) habitats (Figure 26 and 28). There was a general increase in Red Grouper density with increasing depth, with the greatest densities recorded from the 16-20m, 21-25m, and 26-30m depth ranges Appendix 9). However, this was not associated with an increase in size.

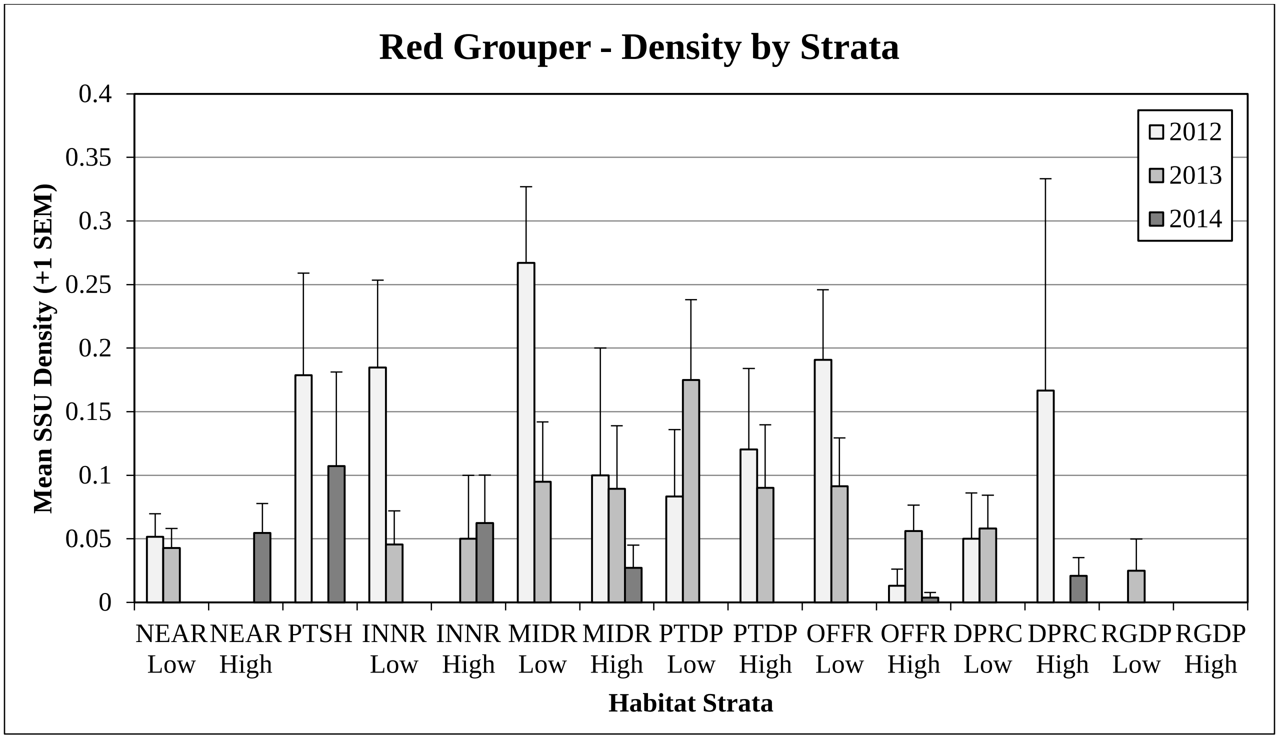

Figure 25. *Red Grouper (*Epinephelus morio*) total mean density per habitat strata; yearly comparison.*

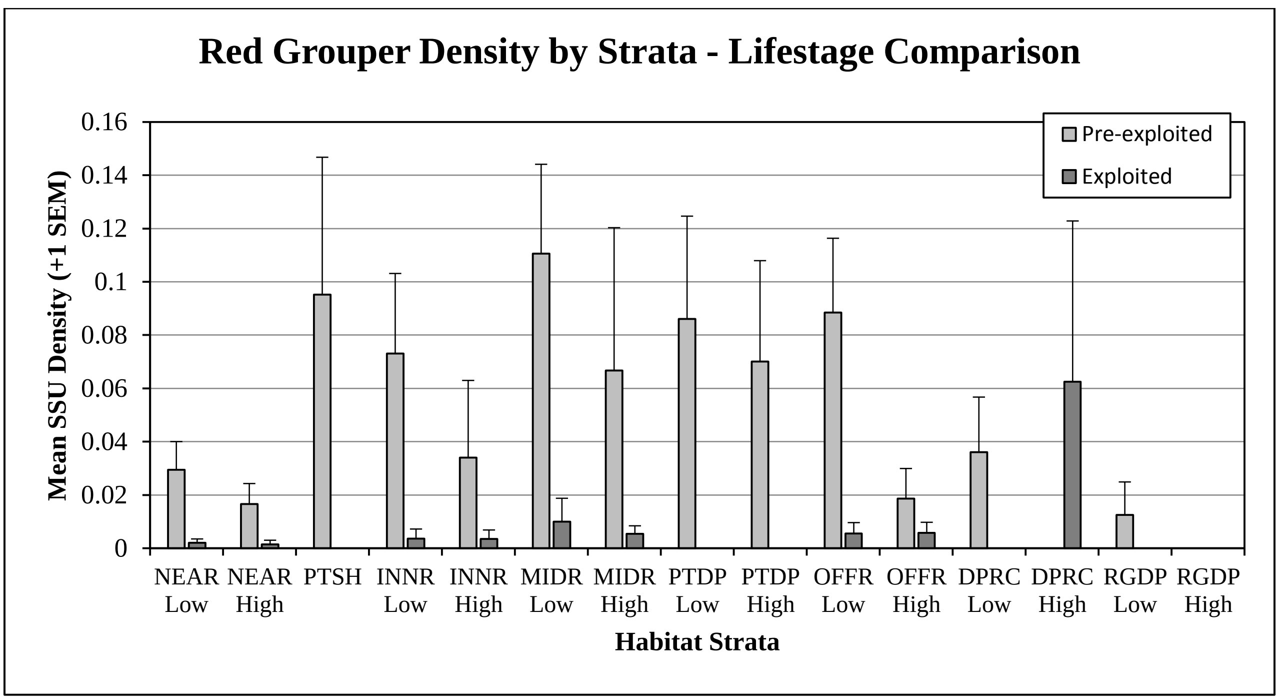

Figure 26. *Red Grouper (*Epinephelus morio*) total mean density per habitat strata; pre-exploited and exploited lifestage comparison; 2012-2014 combined.*

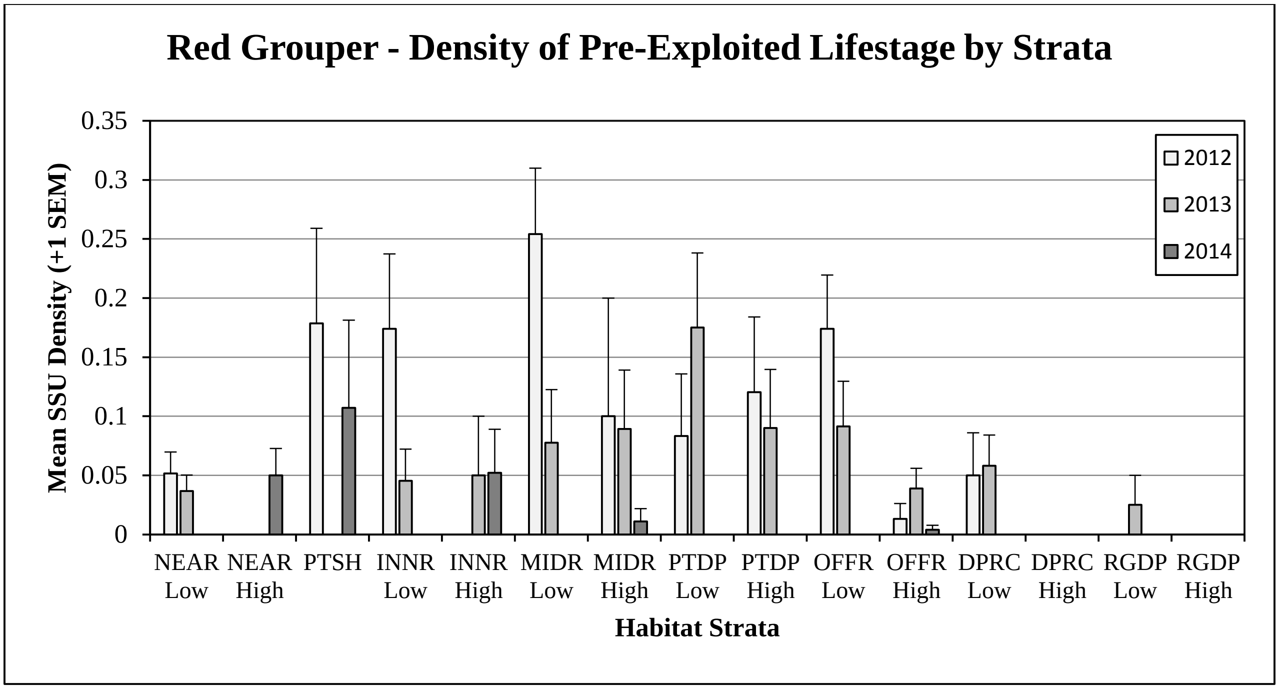

Figure 27. *Red Grouper (*Epinephelus morio*) total mean density per habitat strata; pre-exploited lifestage comparison only.*

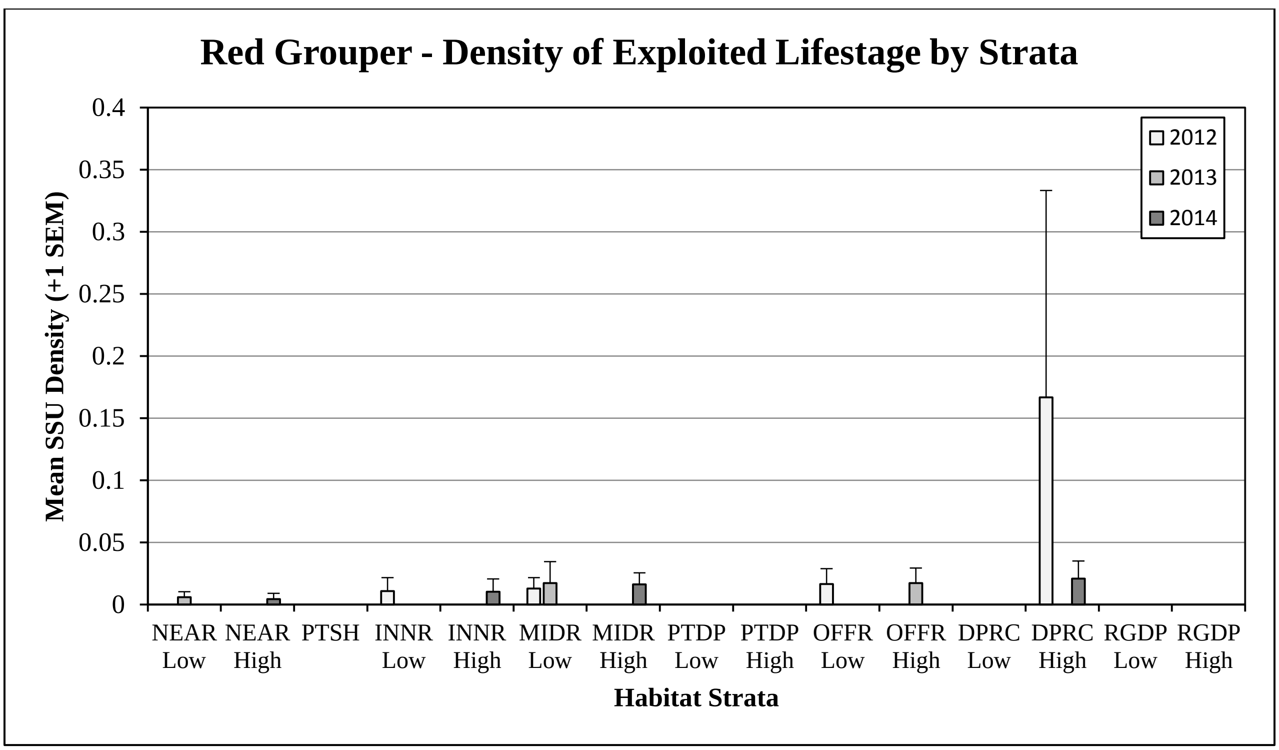

Figure 28. *Red Grouper (*Epinephelus morio*) total mean density per habitat strata; exploited lifestage comparison only.*

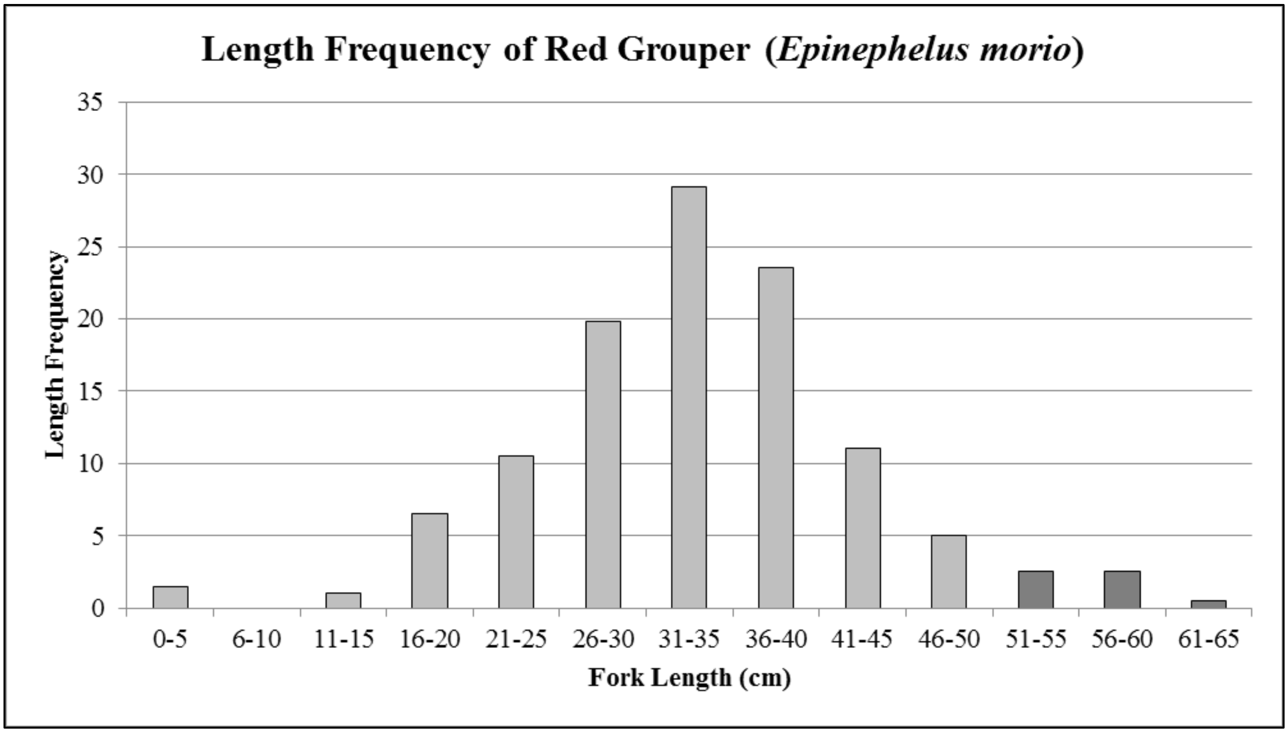

Figure 29. *Length frequency of Red Grouper (*Epinephelus morio*) by size class. Darker gray indicates exploited size classes; legal minimum size of harvest for this species is 50 cm.*

4.1.7. Exploited Species: White Grunt

White Grunt (*Haemulon plumierii*) was the 12th most frequently observed species, with an average percent occurrence ($\bar{P}$) of 40.5 and average density ($\bar{D}$) of 1.5 fishes/SSU (Appendix 6). Comparatively, the data suggest that southeast FL has fewer white grunts than the FL Keys ($\bar{P}$=73.5, $\bar{D}$=8.96) and Dry Tortugas ($\bar{P}$=79.6, $\bar{D}$=6.58). Examination of White Grunt densities by habitat strata (Figure 30) reveals, for the most part, a high degree of consistency between all three years and across strata. Greatest densities were recorded on linear reef-inner (INNR) and deep ridge complex (DPRC) habitats, both coinciding with high slope strata. Examination of the pre-exploited and exploited size classes reveals a possible preference for high slope strata (Figures 32 and 33). The average size of exploited-phase individuals was 23.8 cm, and 36.2% of the total number observed qualified as exploited-phase (≥20 cm) (Figure 34). White Grunts within the exploited size range were encountered in every habitat strata (Figure 31). The average size of White Grunts increased marginally but steadily across a longitudinal gradient, with the smallest individuals occurring in the 0-5m depth range and the largest in 26-30m (Appendix 10). The greatest densities came from the 26-30m depth range and the Deerfield and South Palm Beach subregions, with the largest individuals being found in North Palm Beach.

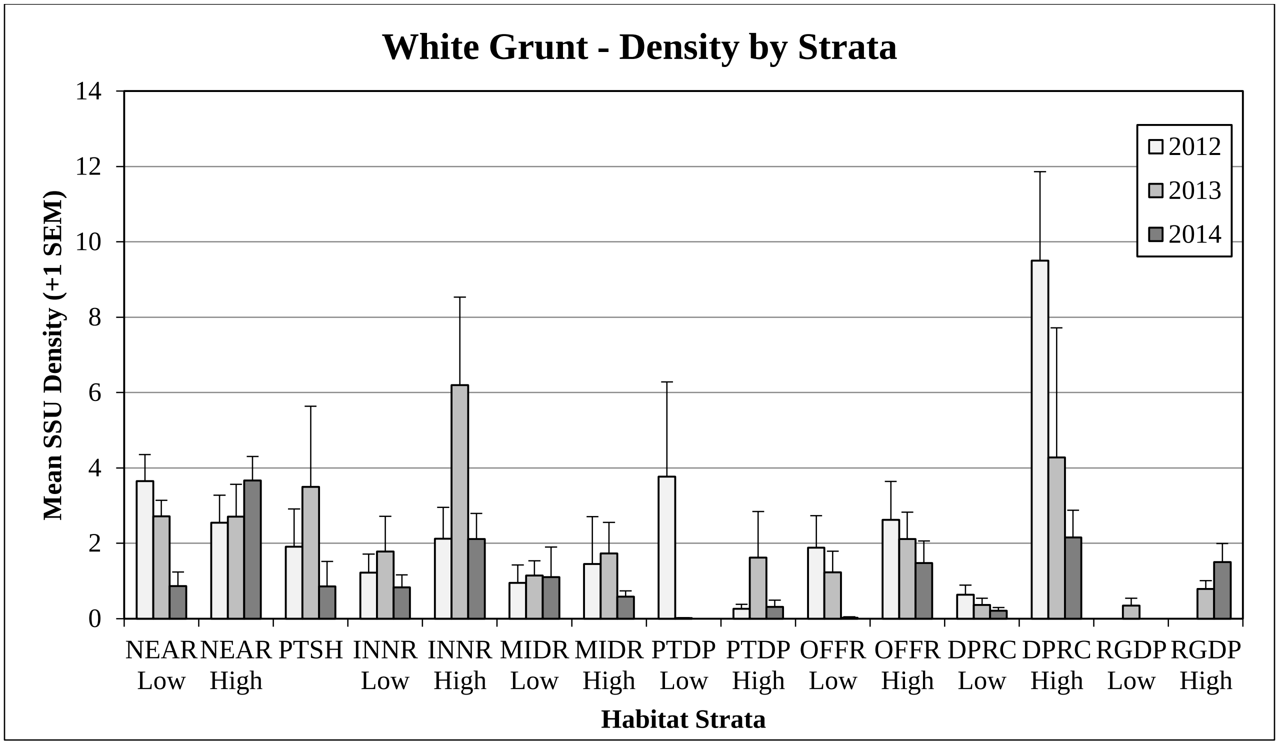

Figure 30. *White Grunt (*Haemulon plumierii*) total mean density per habitat strata; yearly comparison.*

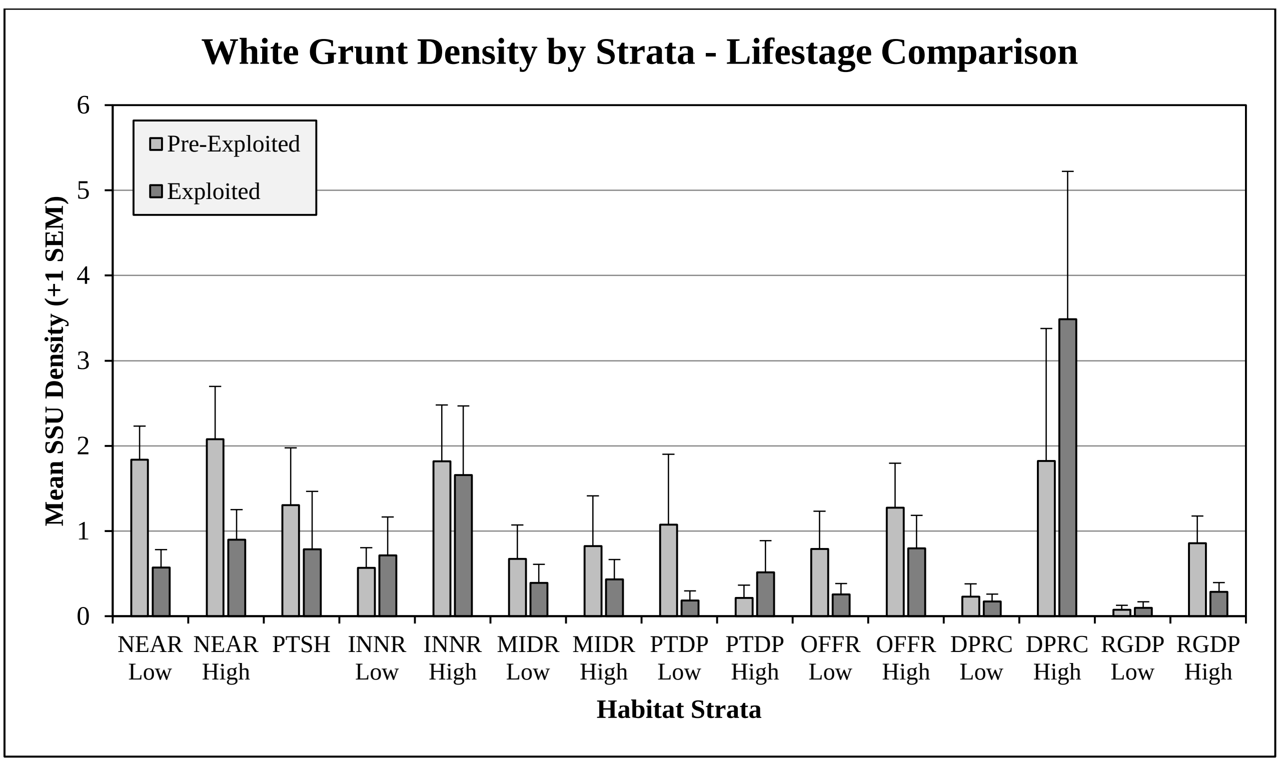

Figure 31. *White Grunt (*Haemulon plumierii*) total mean density per habitat strata; pre-exploited and exploited lifestage comparison; 2012-2014 combined.*

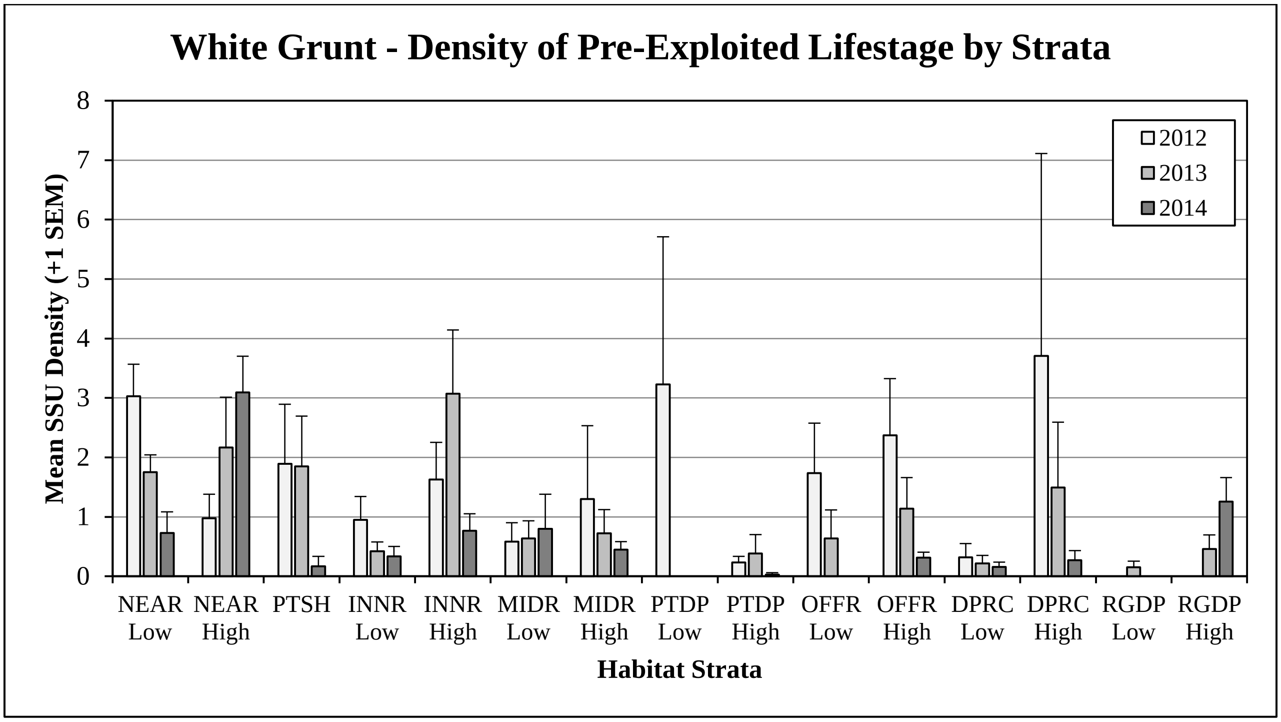

Figure 32. *White Grunt (*Haemulon plumierii*) total mean density per habitat strata; pre-exploited lifestage comparison only.*

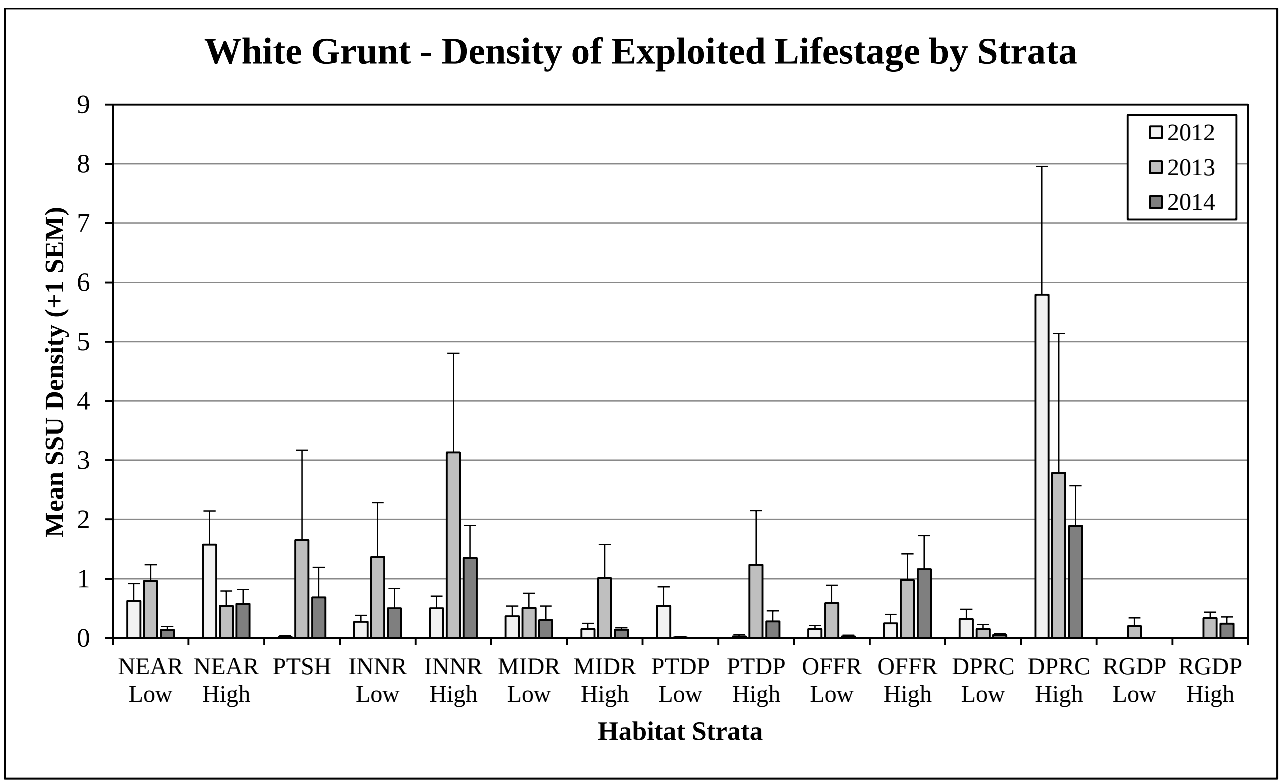

Figure 33. *White Grunt* (Haemulon plumierii) *total mean density per habitat strata; exploited lifestage comparison only.*

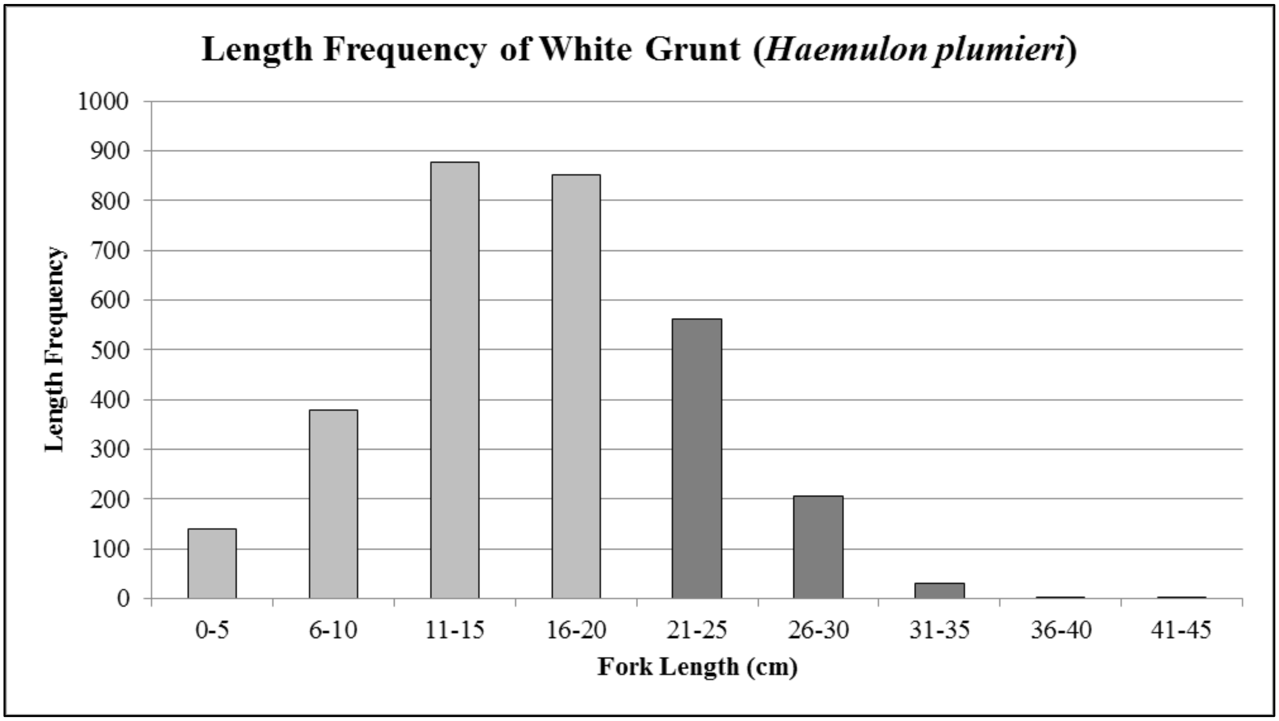

Figure 34. *Length frequency of White Grunt (*Haemulon plumierii*) by size class. Darker gray indicates exploited size classes; estimated minimum size of the exploited phase for this species is 20 cm.*

4.1.8. Exploited Species: Bluestriped Grunt

Bluestriped Grunts (*Haemulon sciurus*) were not as commonly encountered as White Grunts, ranking as the 48th most frequently observed species with an average percent occurrence ($\bar{P}$) of 14.7 and average density ($\bar{D}$) of 1.07 fishes/SSU (Appendix 6). Percent occurrence of this species in the FL Keys and Dry Tortugas was below 10%. Comparison of Bluestriped Grunt densities by habitat strata (Figure 35) reveals a moderate amount of inter-annual variation. When low-high slope pairings within strata for pre-exploited and exploited lifestages were compared (Figures 36, 37, and 38) there seemed to be some preference for low slope for the pre-exploited lifestage and high slope for the exploited lifestage. Also, as a general trend, it appears that the smaller grunts were more prevalent in the shallower habitat strata, and the larger individuals favored the deeper areas. However, there was quite a bit of overlap. Bluestriped Grunts from the exploitable size classes were encountered in every habitat strata except ridge deep (RGDP) (Figure 36). The greatest densities for this species were found in the South Palm Beach subregion (Appendix 11). The average size of exploited-phase individuals was 24.2 cm, and 45.5% of the total number observed qualified as exploited-phase (≥20 cm) (Figure 39).

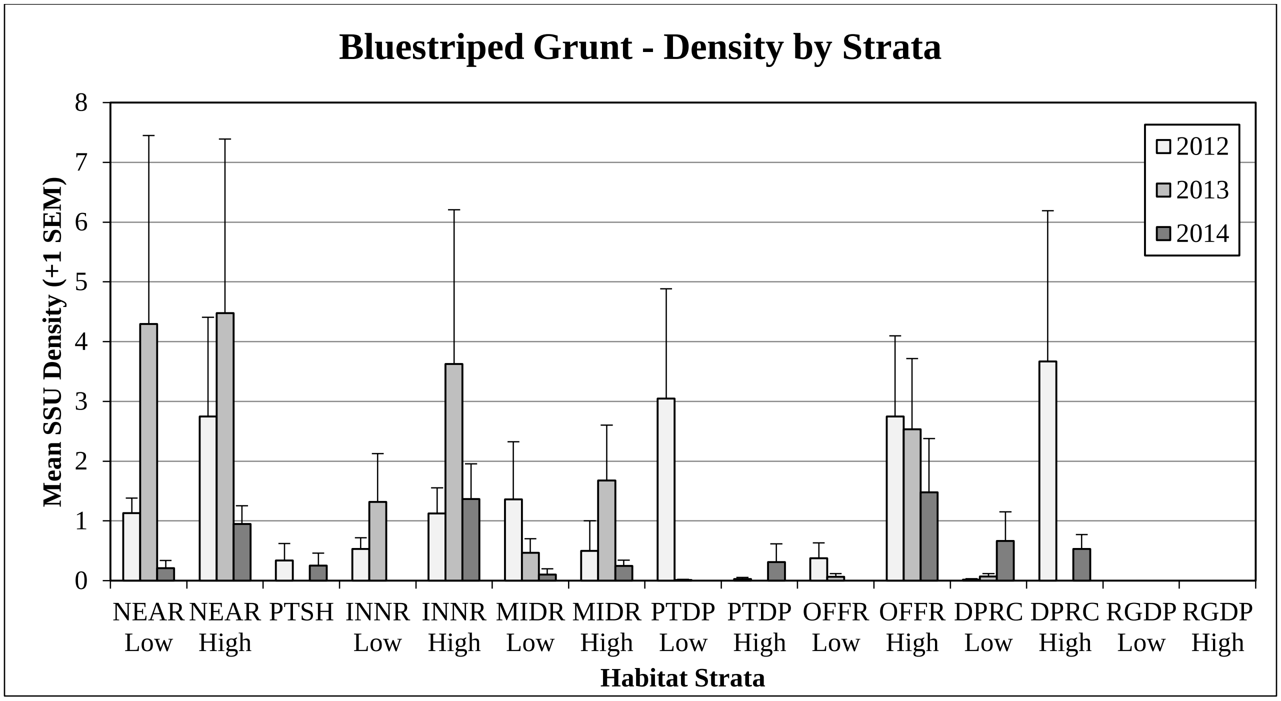

Figure 35. *Bluestriped Grunt (*Haemulon sciurus*) total mean density per habitat strata; yearly comparison.*

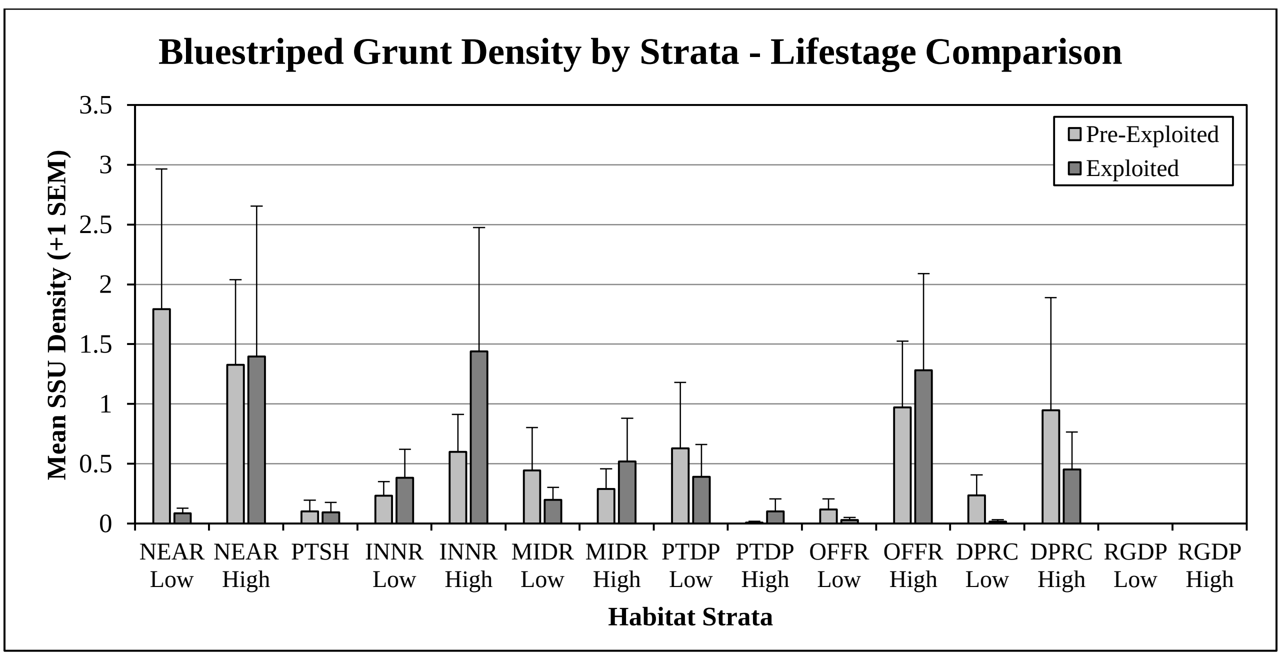

Figure 36. *Bluestriped Grunt (*Haemulon sciurus*) total mean density per habitat strata; pre-exploited and exploited lifestage comparison; 201-2014 combined.*

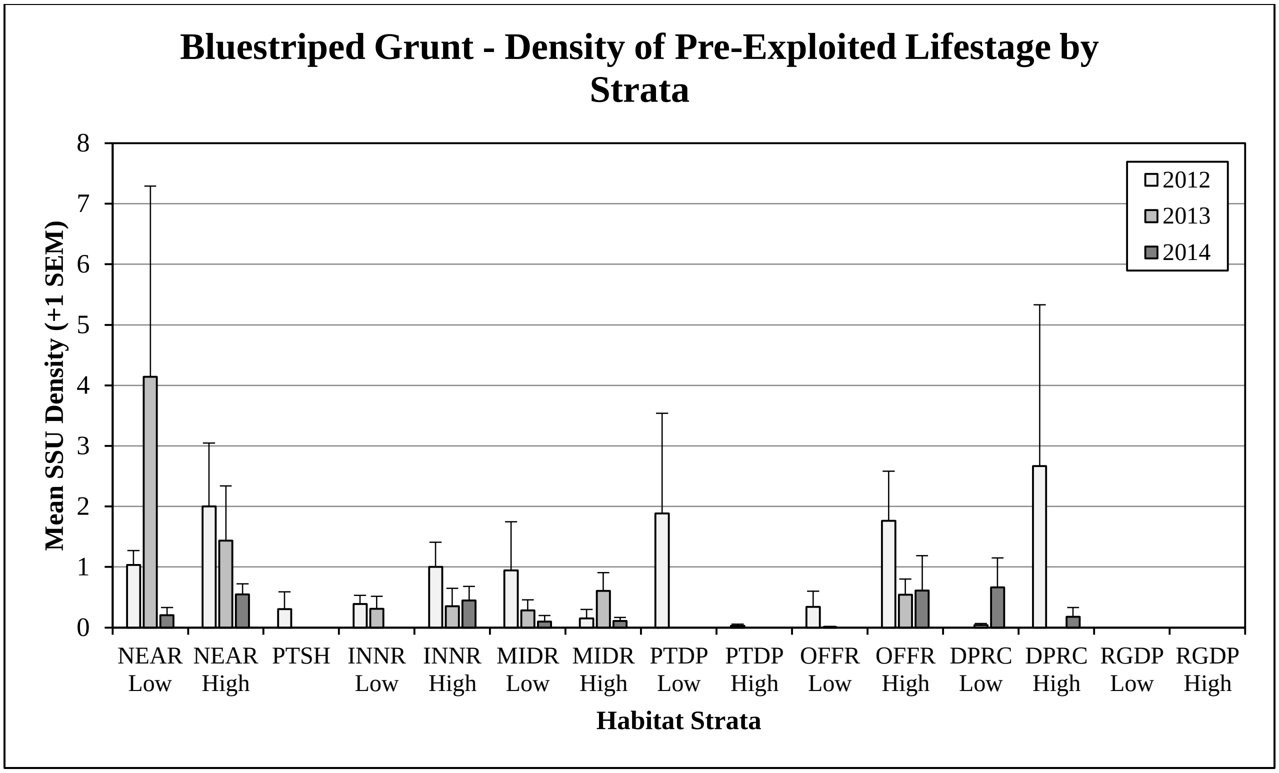

Figure 37. *Bluestriped Grunt (*Haemulon sciurus*) total mean density per habitat strata; pre-exploited lifestage comparison only.*

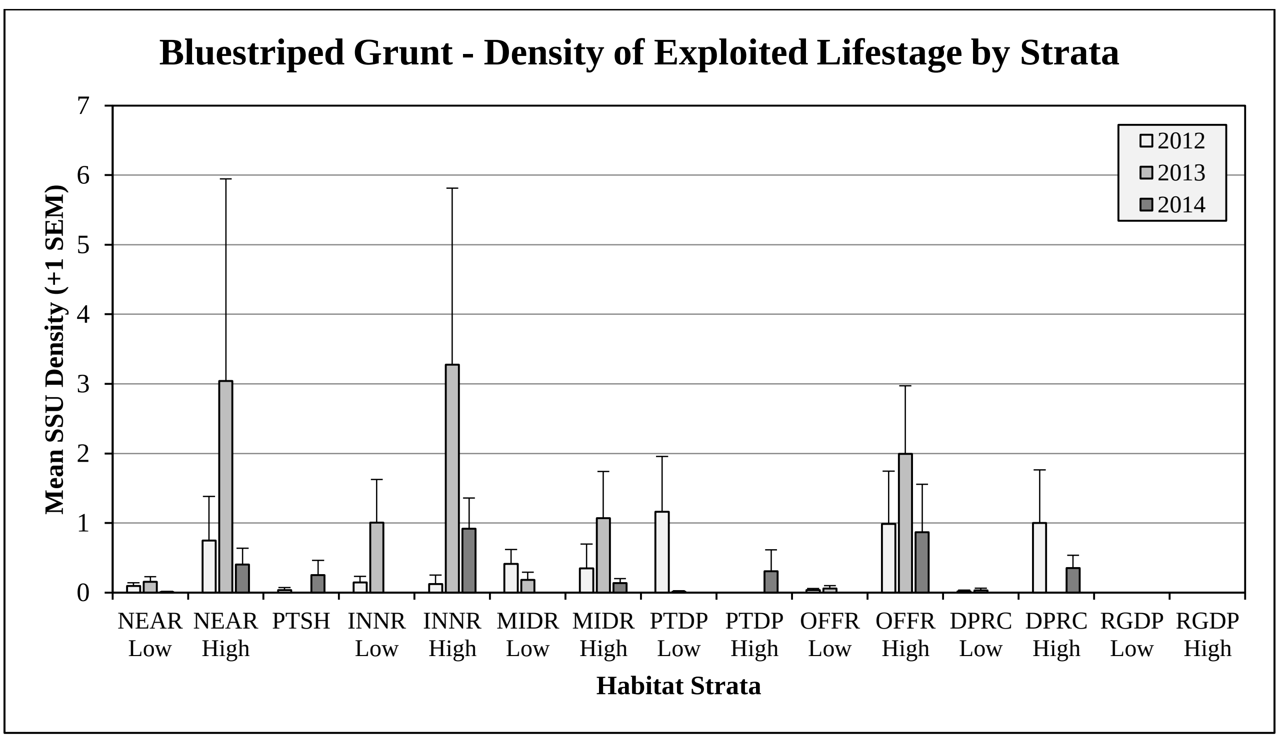

Figure 38. *Bluestriped Grunt (*Haemulon sciurus*) total mean density per habitat strata; exploited lifestage comparison only.*

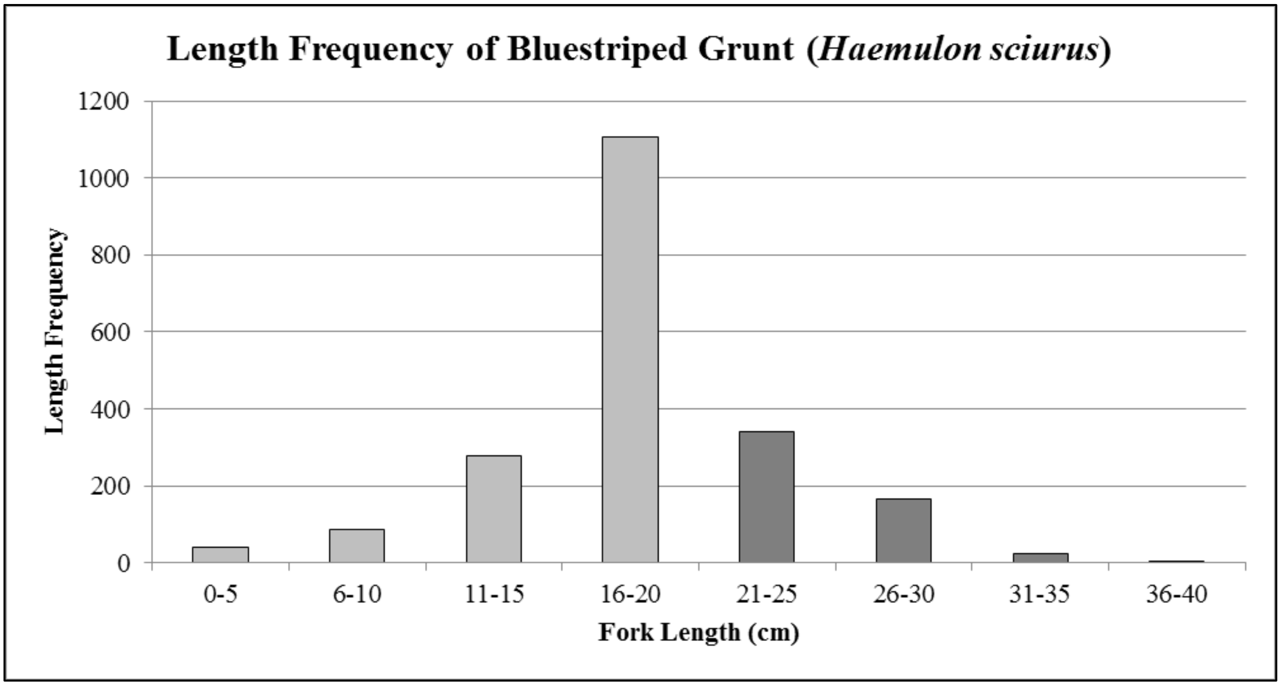

Figure 39. *Length frequency of Bluestriped Grunt (*Haemulon sciurus*) by size class. Darker gray indicates exploited size classes; estimated minimum size of the exploited phase for this species is 20 cm.*

4.1.9. Exploited Species: Hogfish

Hogfish (*Lachnolaimus maximus*) was the 33rd most frequently observed species, with an average percent occurrence ($\bar{P}$) of 20.5 and average density ($\bar{D}$) of 0.26 fishes/SSU (Appendix 6). Comparatively, the data suggest that southeast FL has fewer hogfish than the FL Keys ($\bar{P}$=62.5, $\bar{D}$=1.15) and Dry Tortugas ($\bar{P}$=48.1, $\bar{D}$=0.55). Examination of Hogfish densities by habitat strata (Figure 40) reveals a considerable amount of inter-annual variation, with 2013 exhibiting the greatest densities in almost every case. When low-high slope pairings within strata are compared, there does not seem to be any increased association with high slope in any habitat strata, except for perhaps the deeper strata. The average size of exploited-phase individuals was 34.1 cm, and 23.9% of the total number observed qualified as exploited-phase (≥30 cm). Hogfish of legal size were encountered in every habitat strata except RGDP-low, with the greatest concentration of individuals from both lifestages occurring in the INNR, MIDR, and OFFR strata. Mean fork length of Hogfish increased from south to north. Greatest densities were recorded in the 16-20m and 21-25m depth ranges. Also, it is interesting to note that the largest individuals occurred in both the shallowest (0-5m) and deepest (26-30m) depth ranges (Appendix 12).

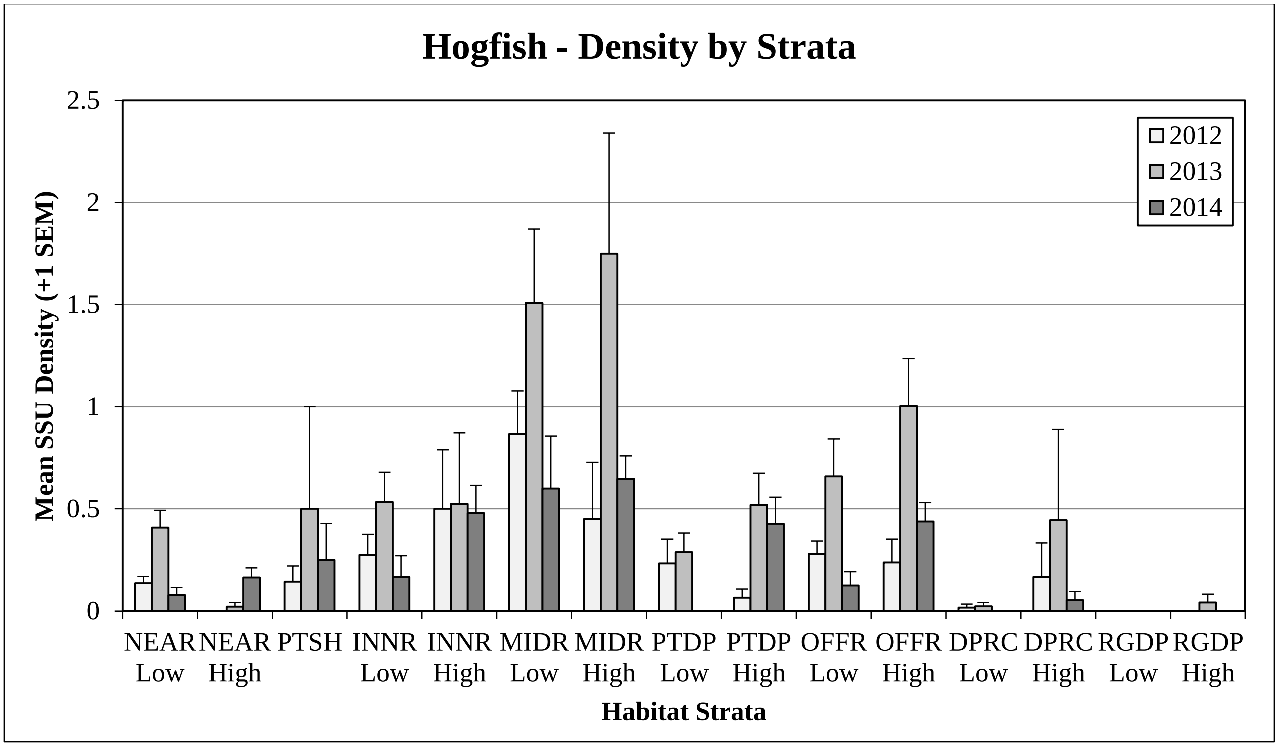

Figure 40. *Hogfish (*Lachnolaimus maximus*) total mean density per habitat strata; yearly comparison.*

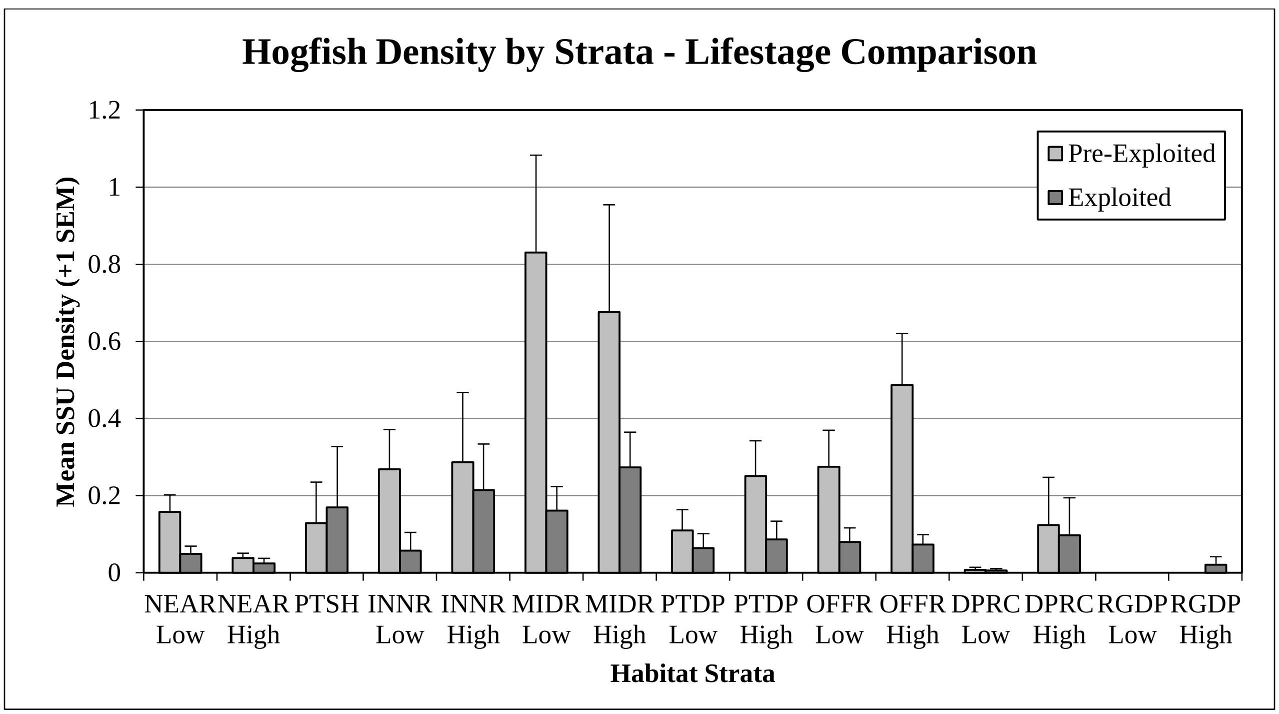

Figure 41. *Hogfish (*Lachnolaimus maximus*) total mean density per habitat strata; pre-exploited and exploited lifestage comparison; 2012-2014 combined.*

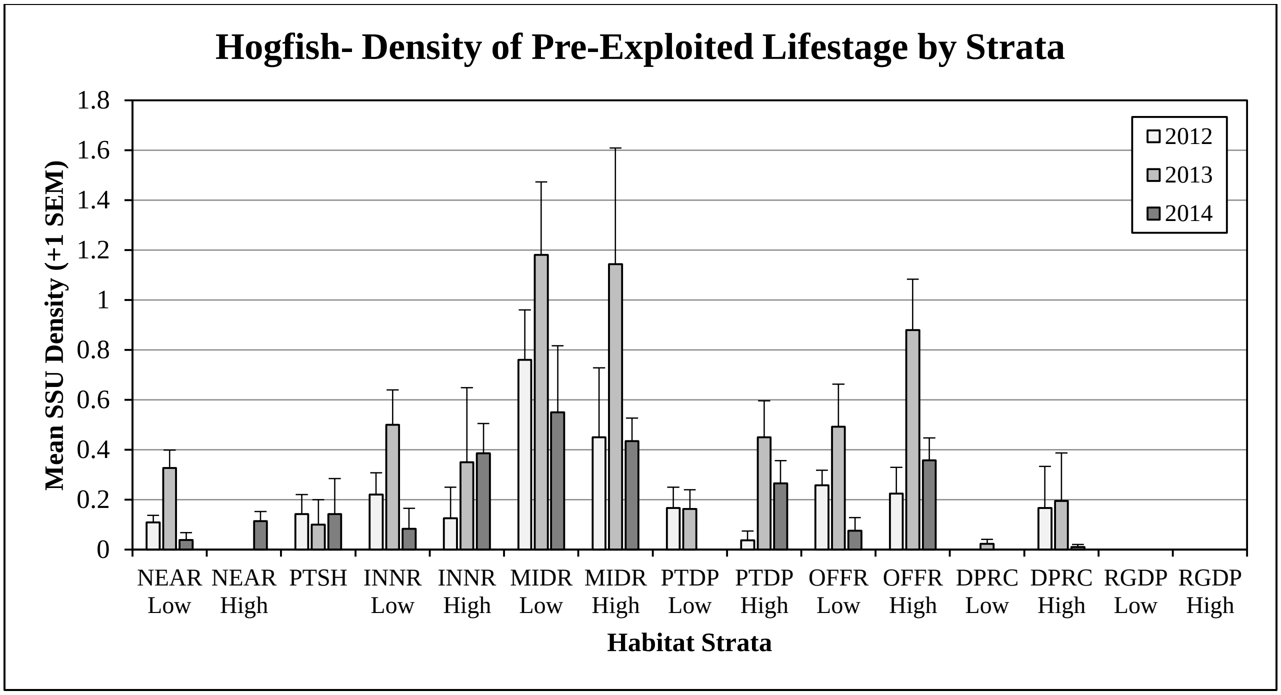

Figure 42. *Hogfish (*Lachnolaimus maximus*) total mean density per habitat strata; pre-exploited lifestage comparison only.*

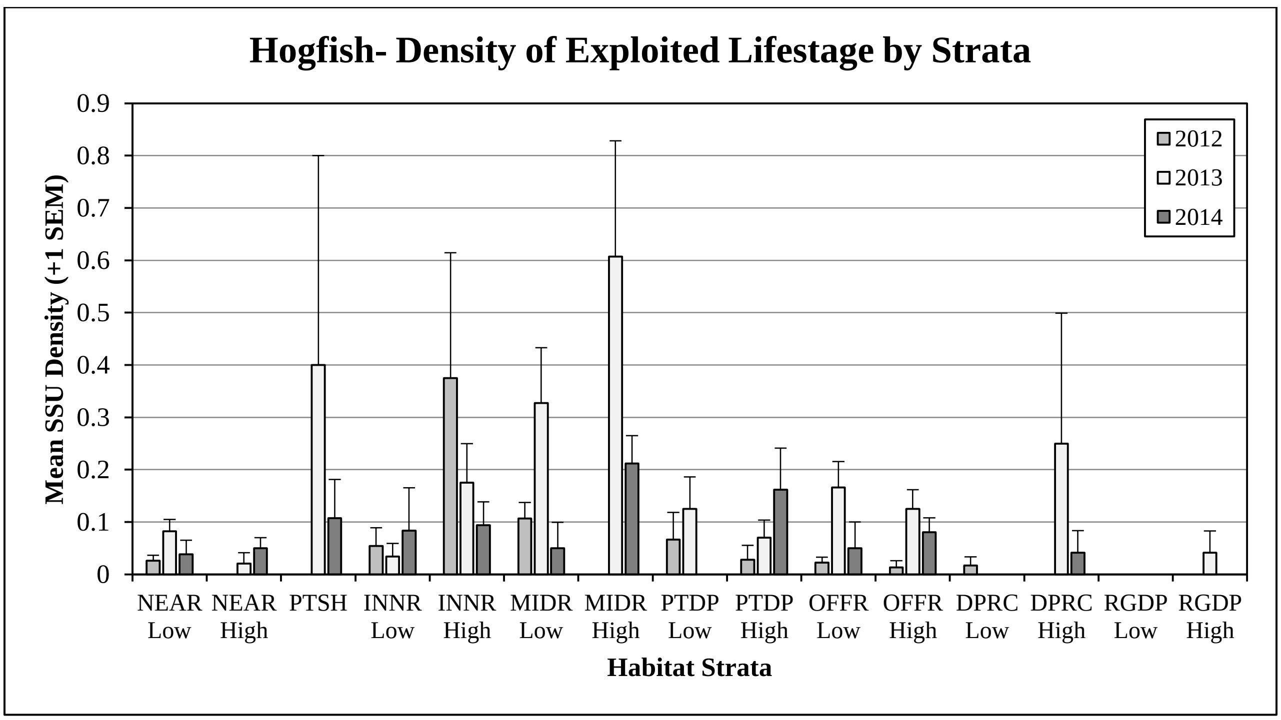

Figure 43. *Hogfish (*Lachnolaimus maximus*) total mean density per habitat strata; exploited lifestage comparison only.*

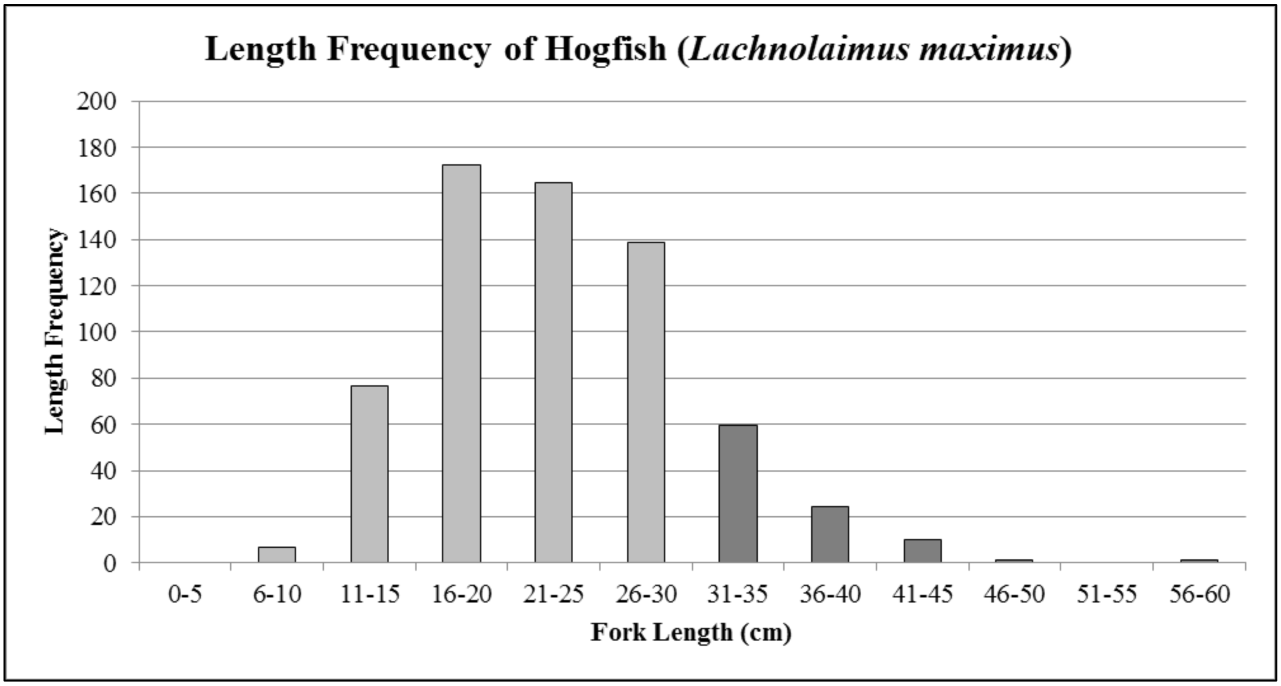

Figure 44. *Length frequency of Hogfish (*Lachnolaimus maximus*) by size class. Darker gray indicates exploited size classes; legal minimum size of harvest for this species is 30 cm.*

4.1.10. Exploited Species: Mutton Snapper

Mutton Snapper (*Lutjanus analis*) was the 26th most frequently observed species, with an average percent occurrence ($\bar{P}$) of 25.5 and average density ($\bar{D}$) of 0.27 fishes/SSU (Appendix 6). Comparatively, the data suggest that southeast FL has more Mutton Snappers than the FL Keys ($\bar{P}$=17.8, $\bar{D}$=0.18) and Dry Tortugas ($\bar{P}$=22.8, $\bar{D}$=0.19). Examination of Mutton Snapper densities by habitat strata (Figure 45) reveals a moderate amount of inter-annual variation. When low-high slope pairings within strata are compared, there is no apparent association with low versus high-slope habitats. This seems to apply to both the pre-exploited and exploited lifestages equally (Figures 47 and 48). The average size of exploited-phase individuals was 44.5 cm, and 23.8% of the total number observed qualified as legal size (≥40 cm) (Figure 49). Mutton Snappers of legal size were encountered in every habitat strata (Figure 46). In addition, the data suggest that there may be a gradient of increasing size with depth, with NEAR habitat holding the smallest individuals and DPRC the largest (Appendix 13).

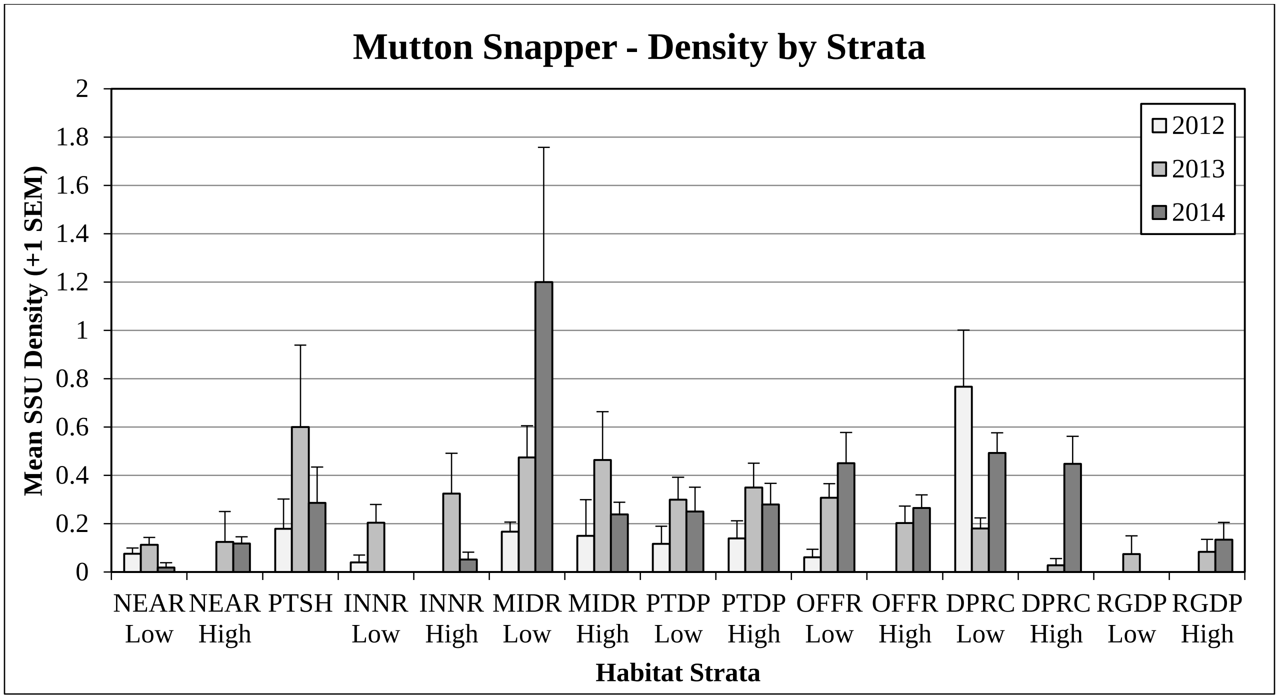

Figure 45. *Mutton Snapper (*Lutjanus analis*) total mean density per habitat strata; yearly comparison.*

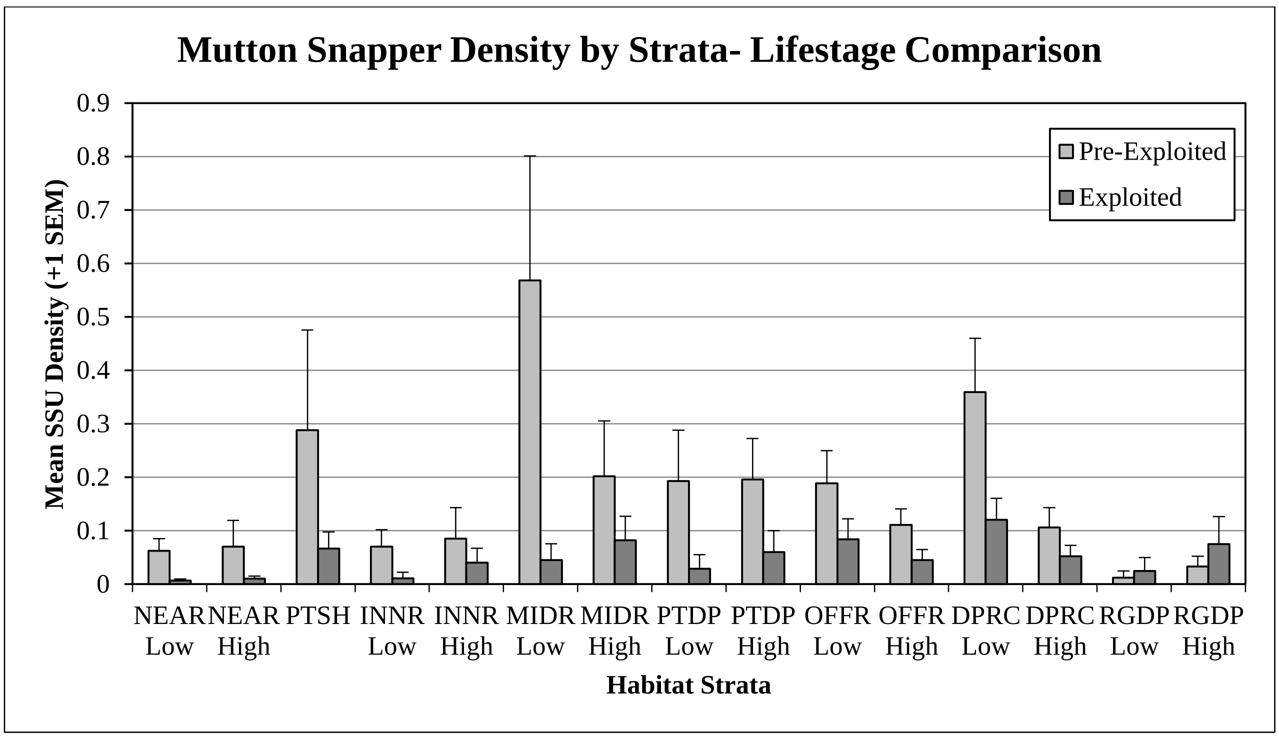

Figure 46. *Mutton Snapper (*Lutjanus analis*) total mean density per habitat strata; pre-exploited and exploited lifestage comparison; 2012-2014 combined.*

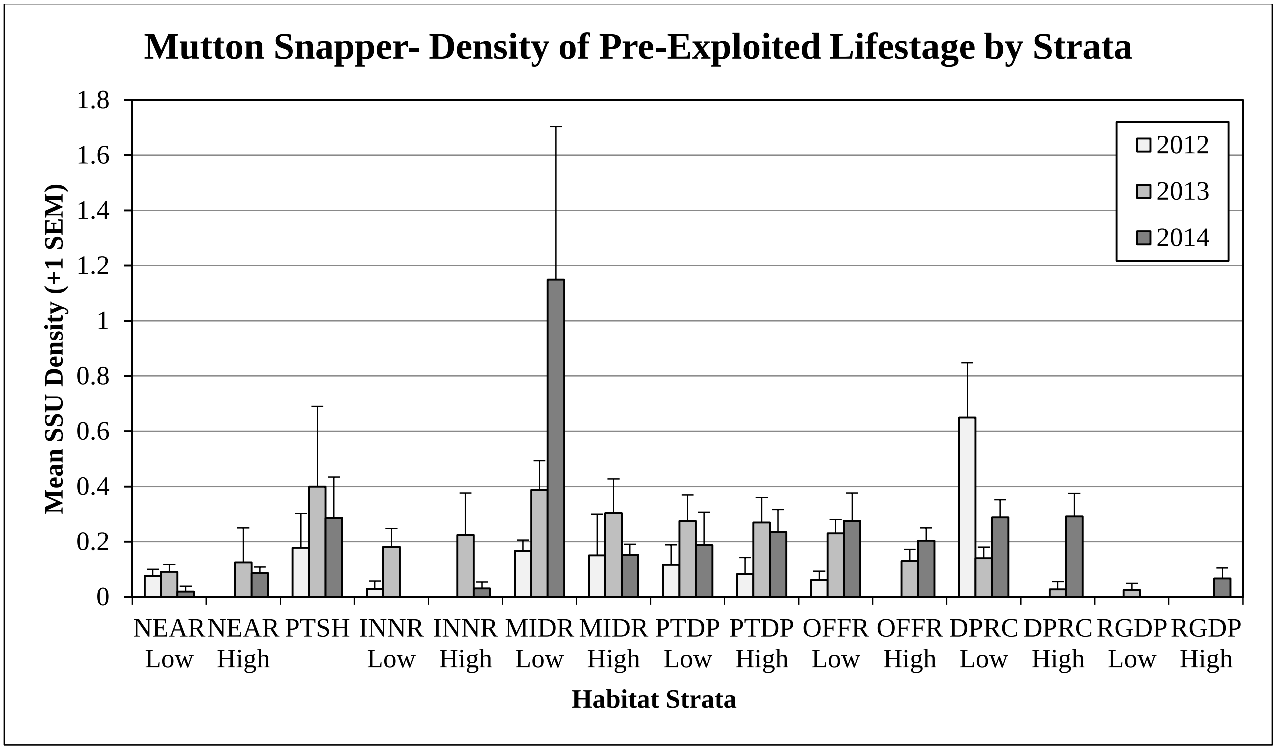

Figure 47. *Mutton Snapper (*Lutjanus analis*) total mean density per habitat strata; pre-exploited lifestage comparison only.*

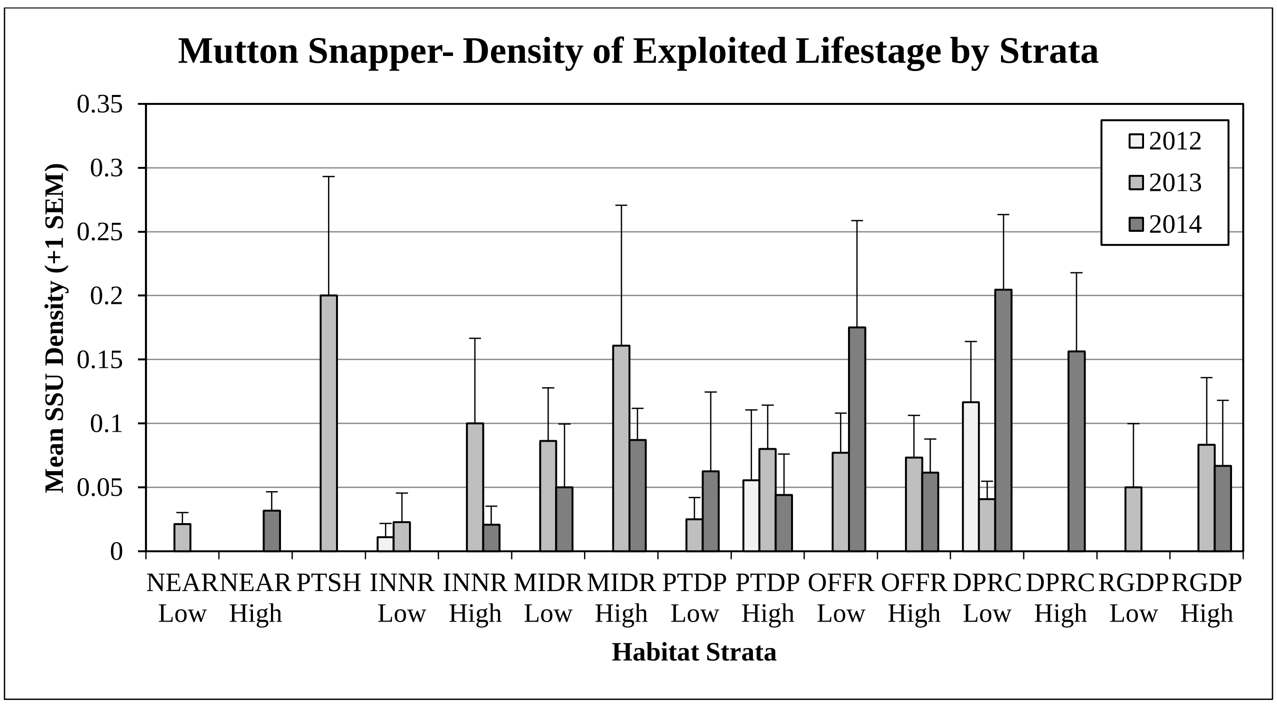

Figure 48. *Mutton Snapper (*Lutjanus analis*) total mean density per habitat strata; exploited lifestage comparison.*

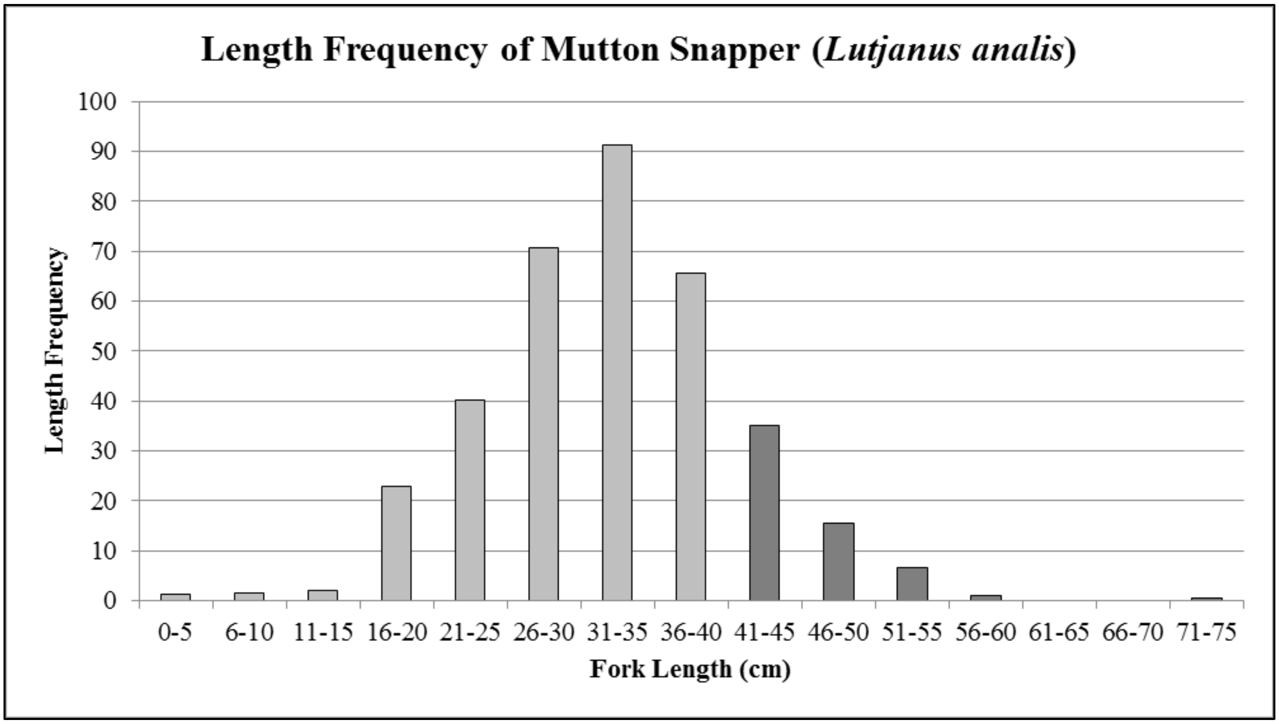

Figure 49. *Length frequency of Mutton Snapper (*Lutjanus analis*) by size class. Darker gray indicates exploited size classes; legal minimum size of harvest for this species is 40 cm.*

4.1.11. Exploited Species: Gray Snapper

Gray Snapper (*Lutjanus griseus*) was the 72nd most frequently observed species, with an average percent occurrence ($\bar{P}$) of 9.3 and average density ($\bar{D}$) of 0.35 fishes/SSU (Appendix 6). Comparatively, the data suggest that southeast FL has fewer Gray Snappers than the FL Keys ($\bar{P}$=27.5, $\bar{D}$=2.27) and Dry Tortugas ($\bar{P}$=15.2, $\bar{D}$=2.73). Examination of Gray Snapper densities by habitat strata (Figure 50) reveals a moderate amount of inter-annual variation, with the deep ridge complex (DPRC) and ridge-deep (RGDP in Martin County) strata exhibiting the greatest densities. When low-high slope pairings within strata are compared, for the pre-exploited lifestage there does not seem to be any distinct preference for low versus high slope (Figure 52). However, for the exploited lifestage there does seem to be an association with high slope in the deeper habitat strata (Figure 53). Legal size Gray Snappers were encountered in very low numbers throughout all habitat strata, with the exception of patch deep (PTDP) (Figure 51). The greatest number of legal sized individuals occurred in the high slope deep ridge complex (DPRC) and ridge deep (RGDP) strata. The average size of exploited-phase individuals was 29.8 cm, and 33.5% of the total number observed qualified as legal size (≥25 cm) (Figure 54). There was also a trend of increasing size from south to north and from shallow to deep (Appendix 14).

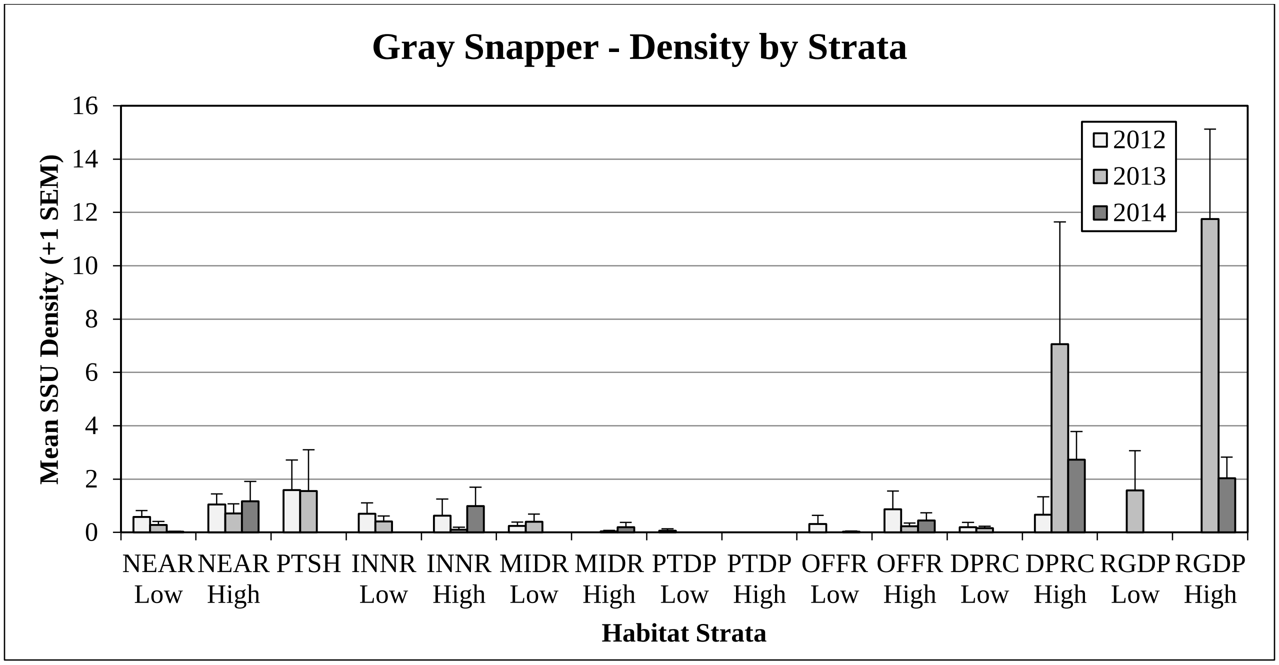

Figure 50. *Gray Snapper (*Lutjanus griseus*) total mean density per habitat strata; yearly comparison.*

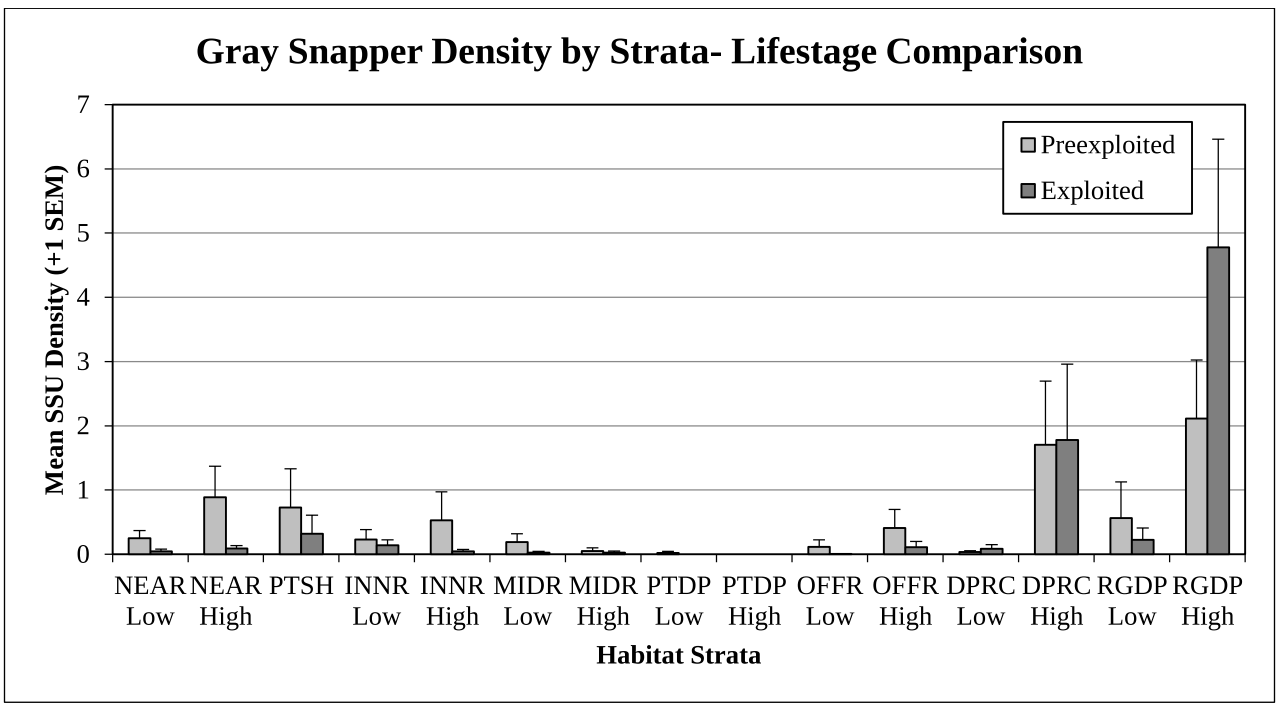

Figure 51. *Gray Snapper (*Lutjanus griseus*) total mean density per habitat strata; pre-exploited and exploited lifestage comparison; 2012-2014 combined.*

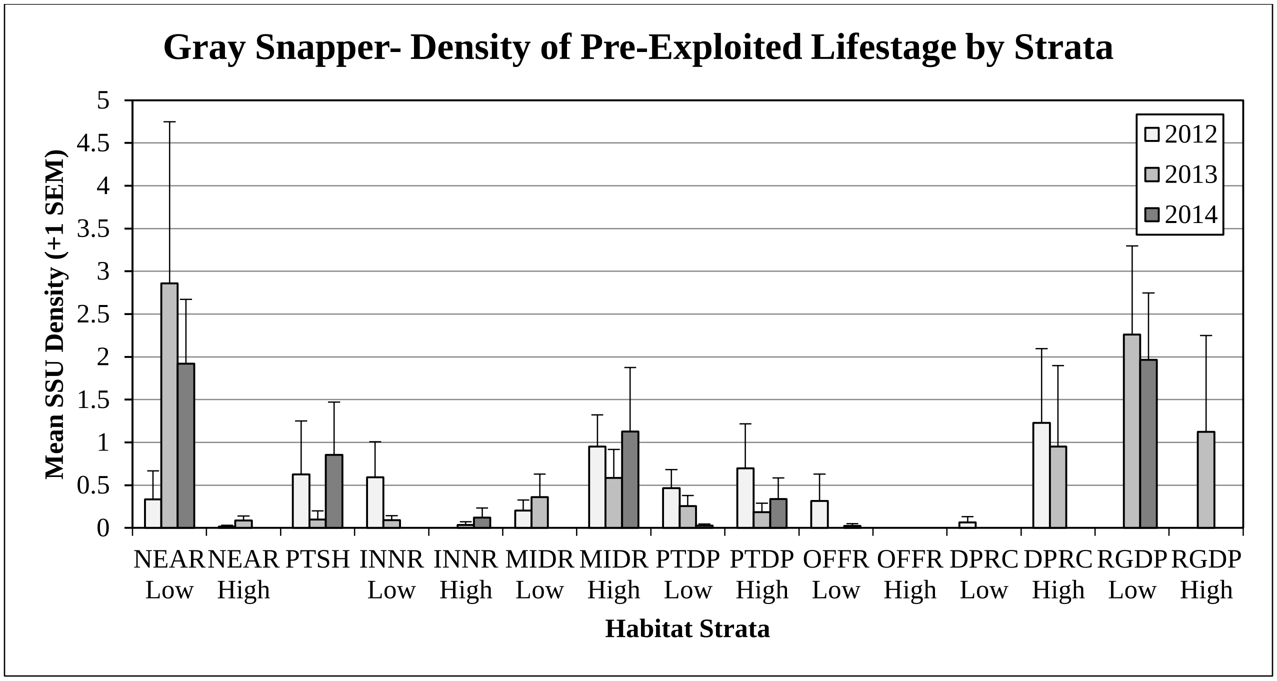

Figure 52. *Gray Snapper (*Lutjanus griseus*) total mean density per habitat strata; pre-exploited lifestage comparison only.*

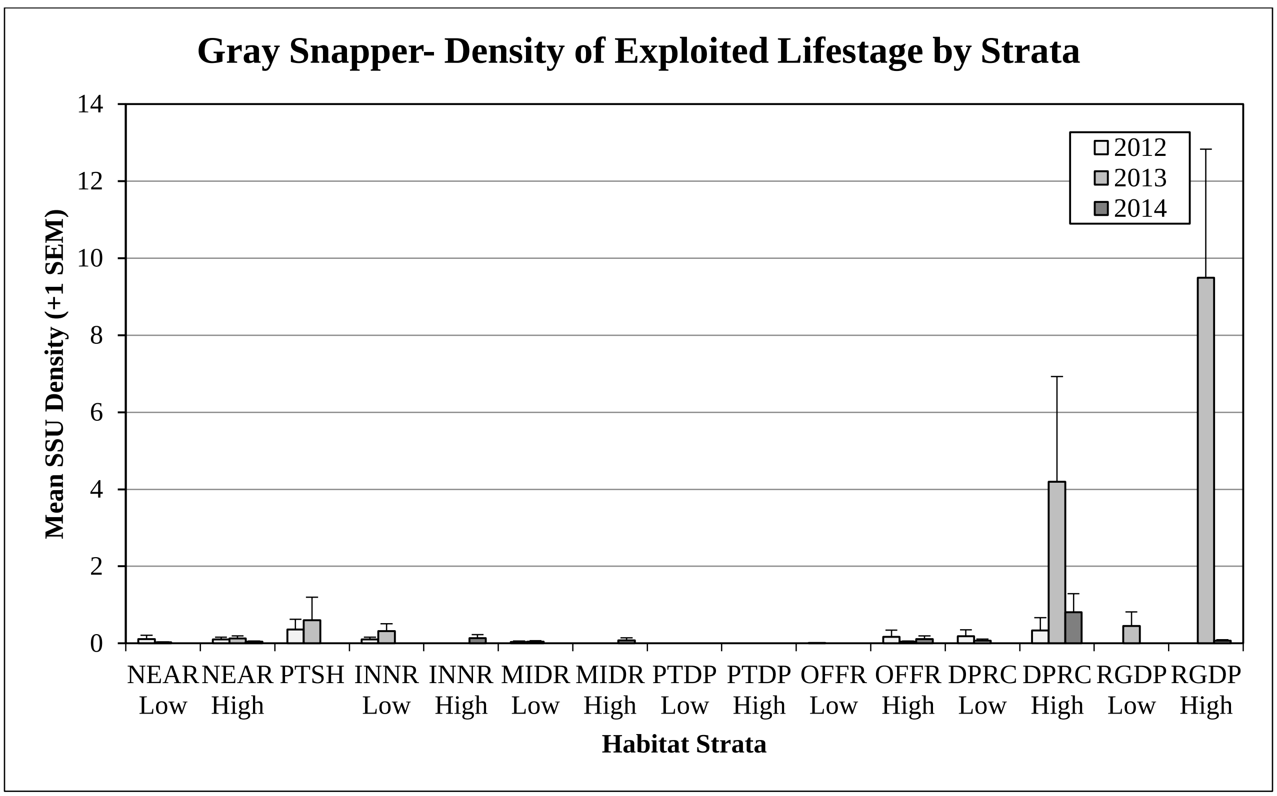

Figure 53. *Gray Snapper (*Lutjanus griseus*) total mean density per habitat strata; exploited lifestage comparison only.*

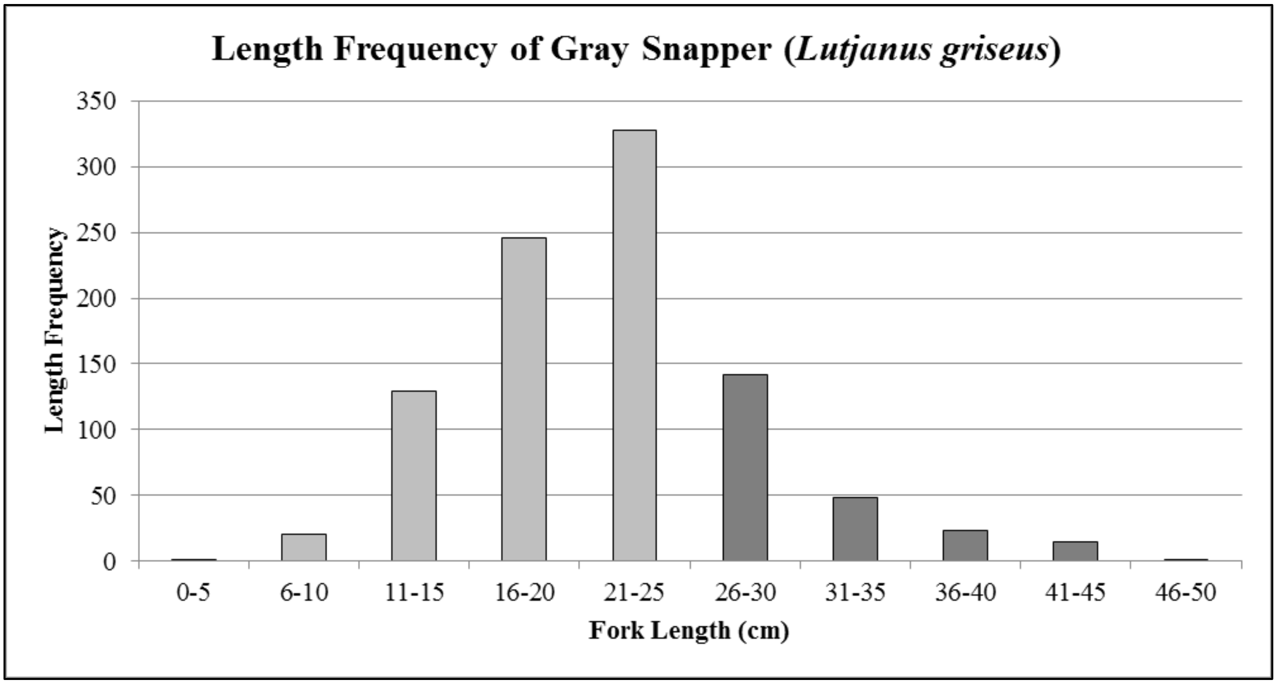

Figure 54. *Length frequency of Gray Snapper (*Lutjanus griseus*) by size class. Darker gray indicates exploited size classes; legal minimum size of harvest for this species is 25 cm.*

4.1.12. Exploited Species: Yellowtail Snapper

Yellowtail Snapper (*Ocyurus chrysurus*) was the 27th most frequently observed species, with an average percent occurrence ($\bar{P}$) of 25.3 and average density ($\bar{D}$) of 1.12 fishes/SSU (Appendix 6). Comparatively, the data suggest that southeast FL has fewer Yellowtail Snappers than the FL Keys ($\bar{P}$=58.5, $\bar{D}$=4.12) and Dry Tortugas ($\bar{P}$=75.7, $\bar{D}$=7.56). Examination of Yellowtail Snapper densities by habitat strata (Figure 55) reveals a moderate amount of inter-annual variation, with more fishes being observed in 2012 and 2013 than in 2014. When low-high slope pairings within strata are compared, there does appear to be a fairly consistent association with high-slope habitats. This seems to be especially applicable to pre-exploited lifestages (Figure 57) and exploited lifestages that occur in the deeper habitats (Figure 58). Yellowtail Snappers of legal size were encountered in every habitat strata, albeit in relatively low numbers, with the fewest occurring in the patch deep (PTDP) strata, and the most occurring in outer reef-linear (OFFR), deep ridge complex (DPRC), and ridge deep (RGDP) strata (Figure 56 and 58). The average size of exploited-phase individuals was 29.4 cm, and 25.4% of the total number observed qualified as legal size (≥25 cm) (Figure 59). Greatest densities occurred in the South Palm Beach subregion, in the OFFR habitat strata, and in the 11-15m depth range. The largest individuals occurred in the 21-25m and 16-20m depth ranges (Appendix 15).

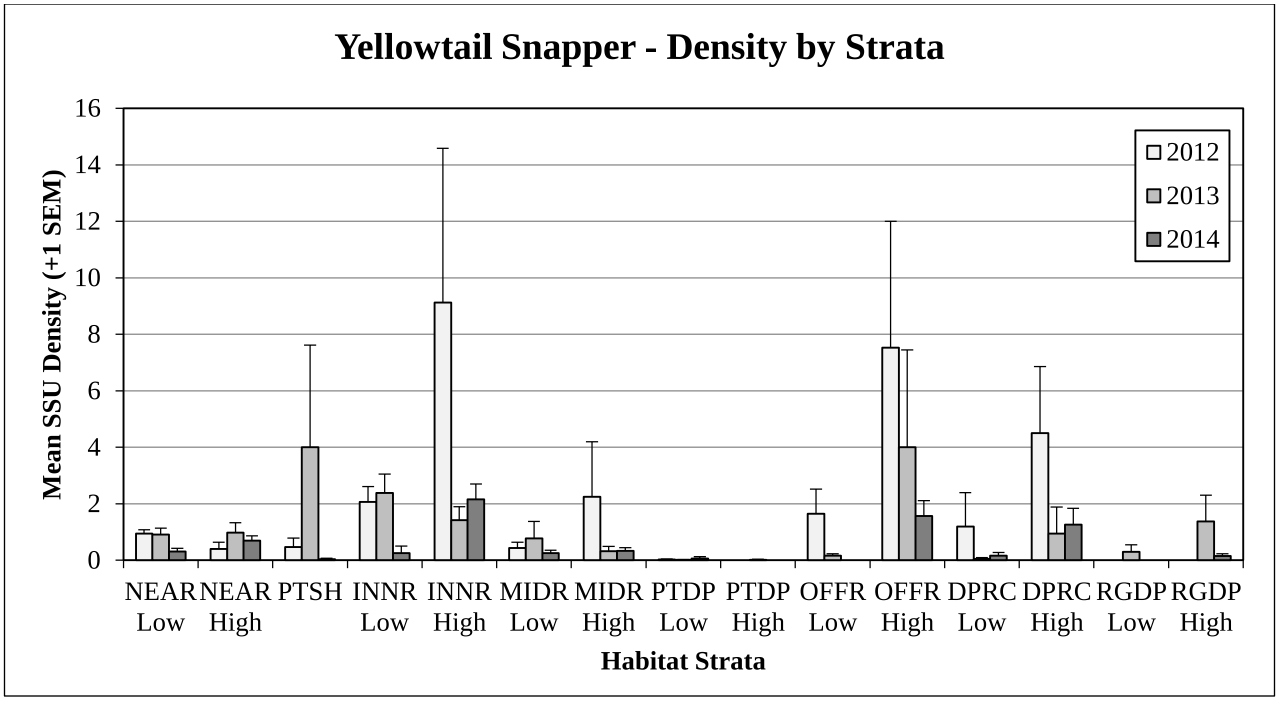

Figure 55. *Yellowtail Snapper (*Ocyurus chrysurus*) total mean density per habitat strata; yearly comparison.*

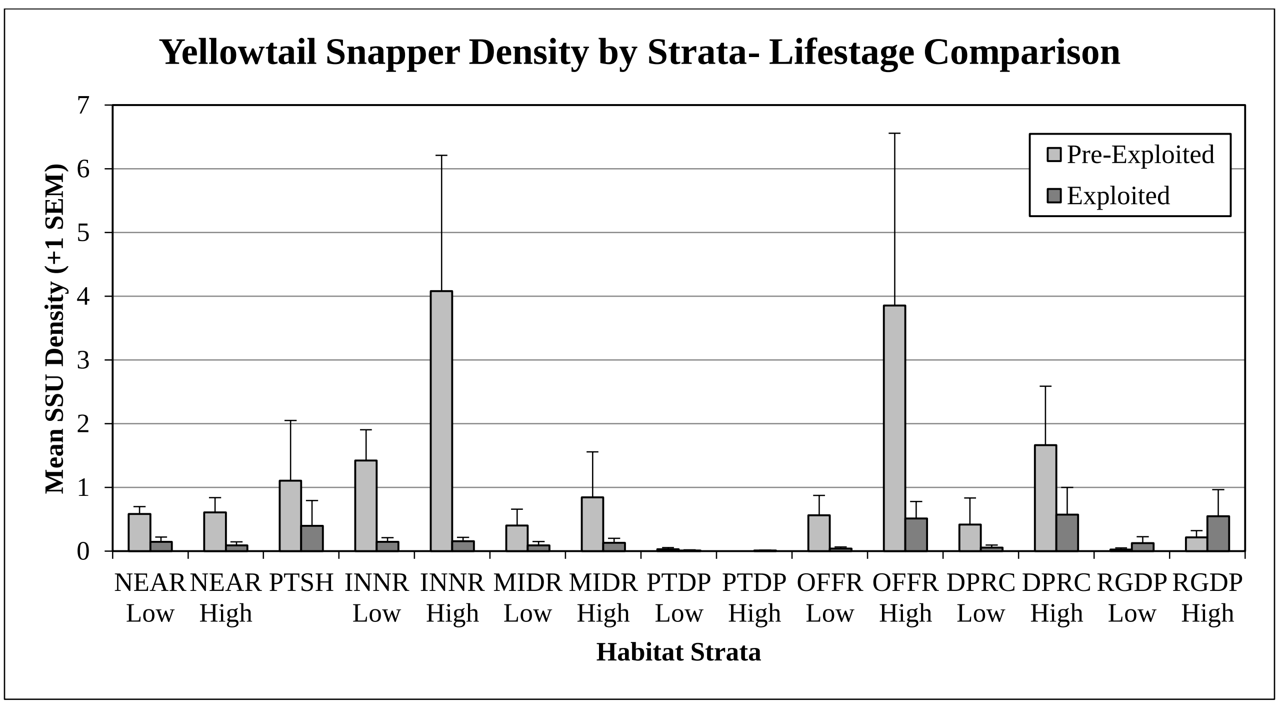

Figure 56. *Yellowtail Snapper (*Ocyurus chrysurus*) total mean density per habitat strata; pre-exploited and exploited lifestage comparison; 2012-2014 combined.*

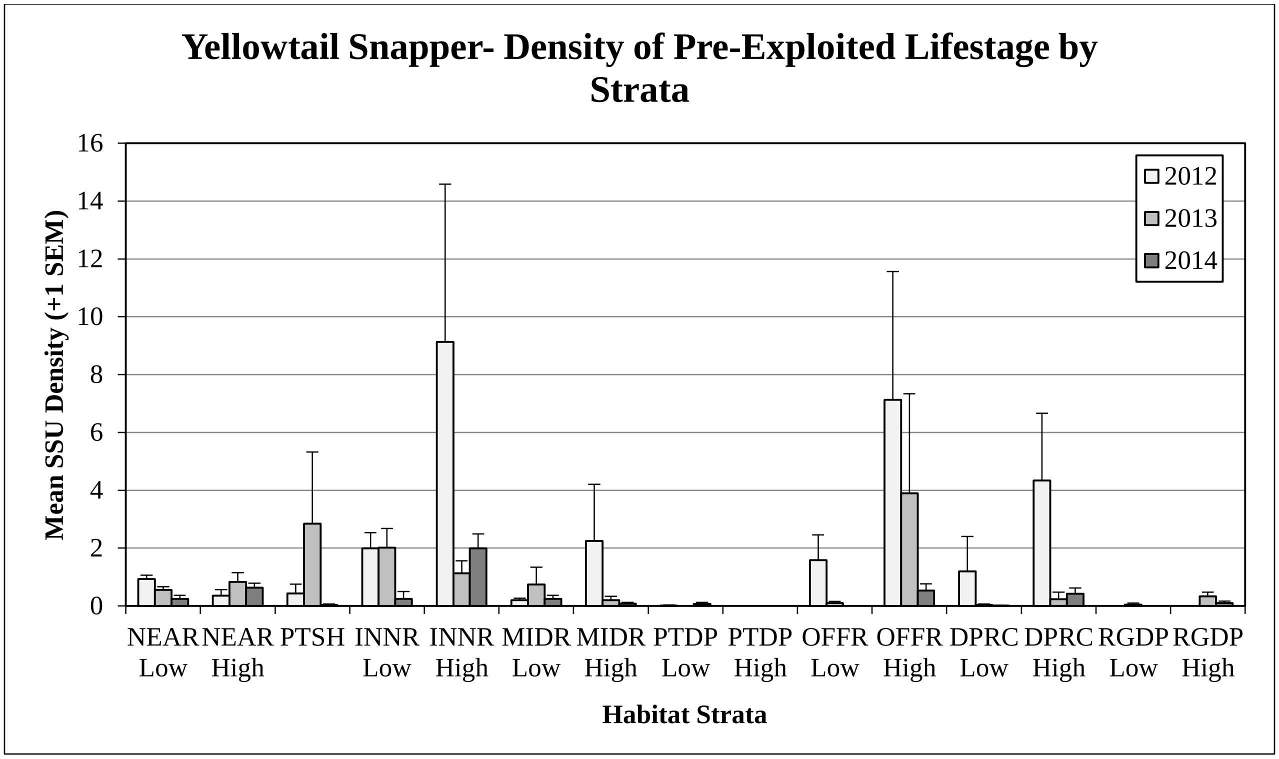

Figure 57. *Yellowtail Snapper (*Ocyurus chrysurus*) total mean density per habitat strata; pre-exploited lifestage comparison only.*

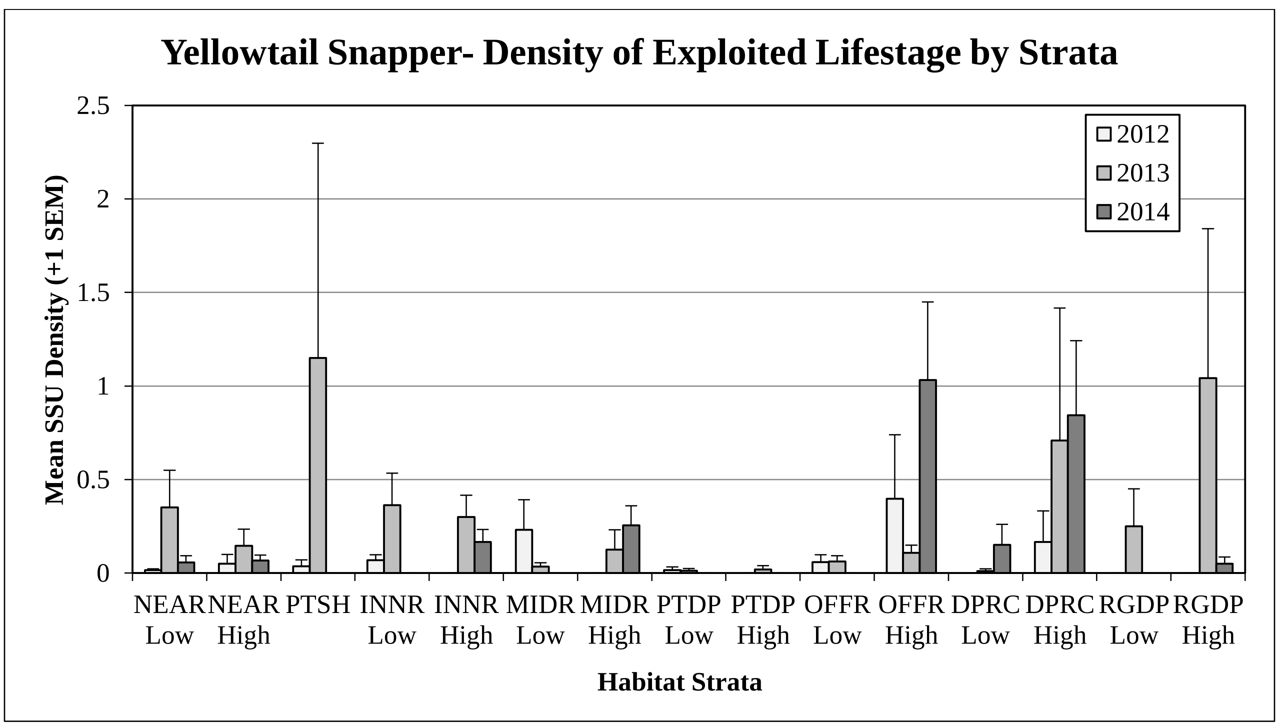

Figure 58. *Yellowtail Snapper (*Ocyurus chrysurus*) total mean density per habitat strata; exploited lifestage comparison only.*

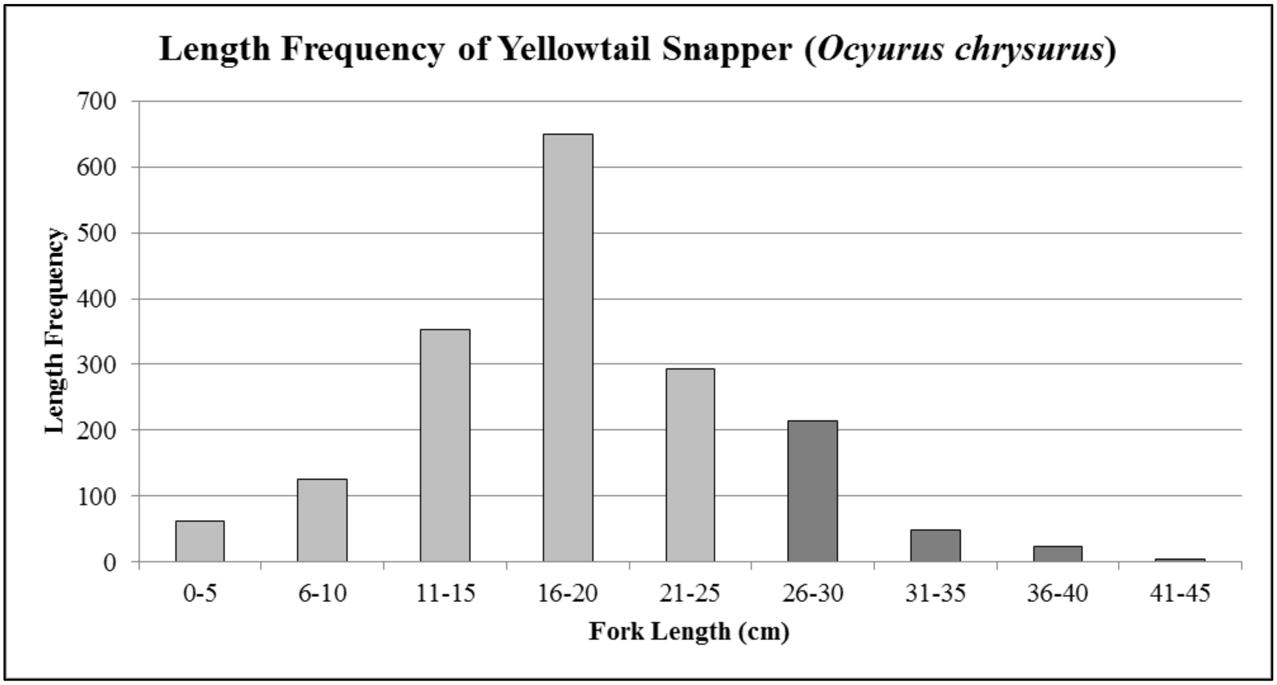

Figure 59. *Length frequency of Yellowtail Snapper (*Ocyurus chrysurus*) by size class. Darker gray indicates exploited size classes; legal minimum size of harvest for this species is 25 cm.*

4.1.13. Discussion of Lionfish

Due to the level of ongoing research and public interest related to the Lionfish invasion in the Western Atlantic, a brief discussion of the data collected for this species (*Pterois* spp. = *Pterois volitans/miles* complex) is included here. Lionfish were the 54th most frequently observed species, with percent occurrence ($\bar{P}$) increasing from 12.5% in 2012 to 13.7% in 2013, and then down to 10.7% in 2014. Mean density ($\bar{D}$) also increased from 0.11 fish/SSU in 2012 to 0.15 fish/SSU in 2013, but then back down to 0.08 fish/SSU in 2014. Multiple reasons could account for the difference between years, including increased sampling effort and the site allocation procedure. When $\bar{\mathrm{P}}$ is compared between strata (Figure 60), it is apparent that the likelihood of encountering a Lionfish generally increases when moving from the shallower habitats towards the deeper ones. This seems to be further supported by an examination of subregional trends, which shows greater occurrence in the subregions that are primarily characterized by greater prevalence of deeper habitats (Figure 61). A general trend of decreasing availability of shallow water coral reef habitats is present as you move from the southern end to the northern end of the survey domain. Consequently, the fact that the South Palm Beach and Martin subregions had the highest occurrence does not directly equate to those areas having more Lionfish; those regions have greater relative percentage of the deeper habitats that the data suggests Lionfish seem to prefer, therefore they are more likely to be encountered. It is also possible that efforts made towards lionfish eradication in the Broward-Miami, Deerfield, and North Palm Beach subregions could be having an impact, but further investigation is needed to support this argument.

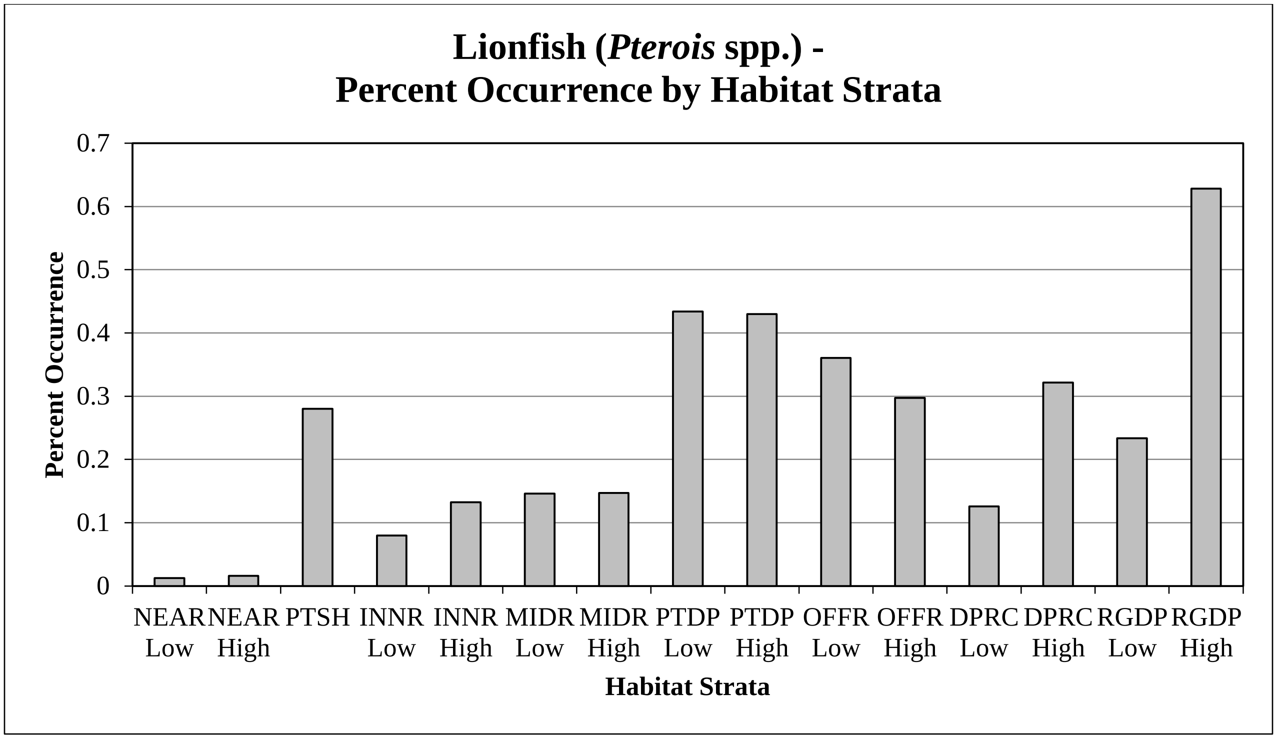

Figure 60. *Percent Occurrence ($\bar{P}$) of Lionfish (*Pterois *spp.) by habitat strata.*

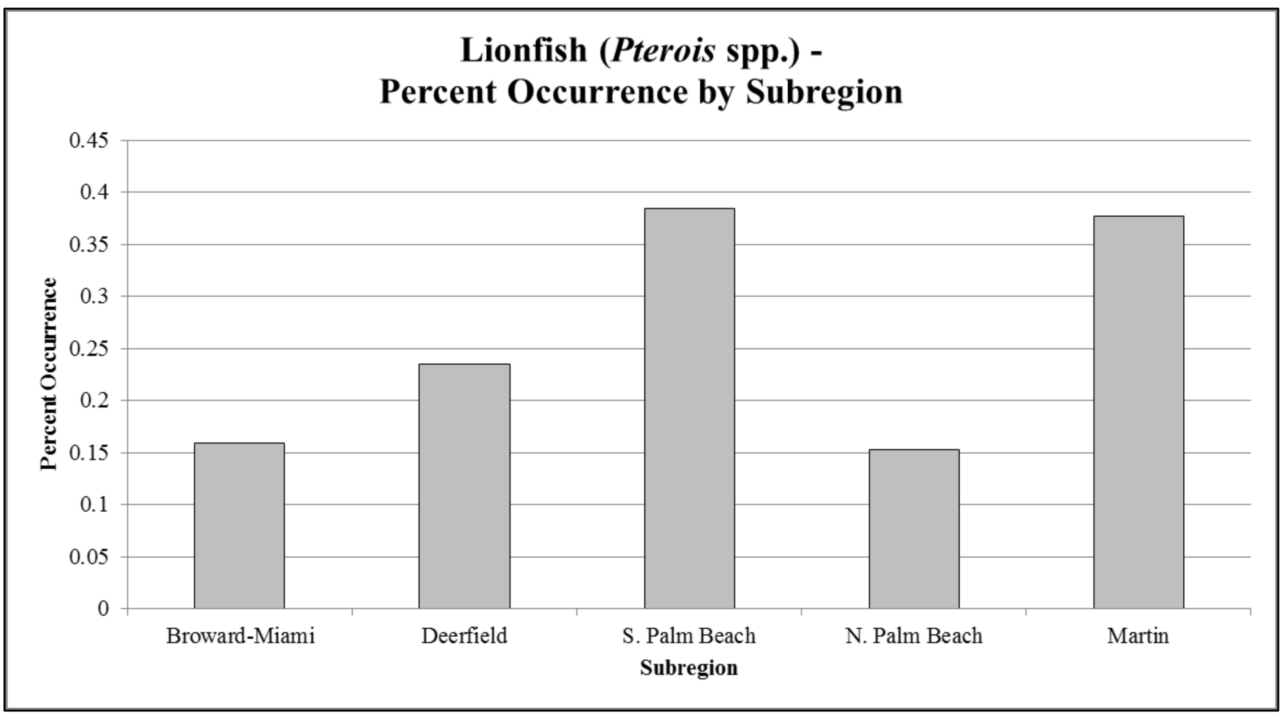

Figure 61. *Percent Occurrence ($\bar{P}$) of Lionfish (*Pterois *spp.) by subregion.*

4.1.14. Comparison of Southeast Florida to the Florida Keys and Dry Tortugas

Based on RVC counts, the species composition of fish assemblages of the FRT (southeast Florida, the Florida Keys, and the Dry Tortugas) are similar (Appendix 6). The 73 species discussed in the Smith et al. (2011) publication on the Florida Keys and the Dry Tortugas were all recorded in this study of the northern portion of the FRT (the species list included in that report was truncated to those fishes that had a mean percent occurrence ($\bar{P}$) greater than 10% in one or both regions). Likewise all but 22 species of 279 recorded in this report have been recorded from the Florida Keys and the Dry Tortugas as well, and those 22 were rare, predominantly single sightings.

Figures 62 and 63 display the percent occurrence ($\bar{P}$) and mean density ($\bar{D}$) values for select species from all 3 sampled regions of the Florida Reef Tract: southeast Florida, the Florida Keys, and the Dry Tortugas. Values represented in the figures are taken from Appendix 6, which utilizes the new data from southeast Florida (i.e., this report) along with previously published data from Smith et al. (2011). The species displayed in these figures include six of the previously discussed target species; Gray Triggerfish and Bluestriped Grunt were not included because they were not seen in the FL Keys and Tortugas in sufficient numbers to make it past the 10% cutoff treatment that was applied to the Smith et al. (2011) dataset. As a general trend, most of these species show a pattern of increasing percent occurrence and density as you move from southeast Florida down through the Florida Keys and into the Dry Tortugas. There was one exception: Mutton Snapper (*L. analis*) had slightly higher $\bar{P}$ and $\bar{D}$ in SE FL. Likewise, two of the targeted species, Red Grouper and Mutton Snapper, have a lower mean length in the exploited phases (Lbar) (see exploited species discussions above) than published Lbar values for Keys fishes. Two of the others are essentially the same, and the final 3 differ by less than 2 cm (Figure 64). Excepting the Yellowtail Snapper these exploited fishes are overfished in the Keys (Ault et al., 2004).

Admittedly, there may be environmentally associated changes in life history of the individual species which would alter relevant parameters for determining Maximum Sustainable Yield (MSY) and the results in this report showing that environment and assemblages differ among sites latitudinally in the northern portion of the FRT may support such a contention. However, the species composition as determined by RVC is extremely similar and the populations of non-targeted species are similar in percent occurrence and density, and in most cases the means of the southern FRT species fall within the Standard Error (SE) of the northern populations (Appendix 6). Thus, the simplest explanation for the low Lbar is that the targeted reef fishes in the northern portion of the FRT are overfished.

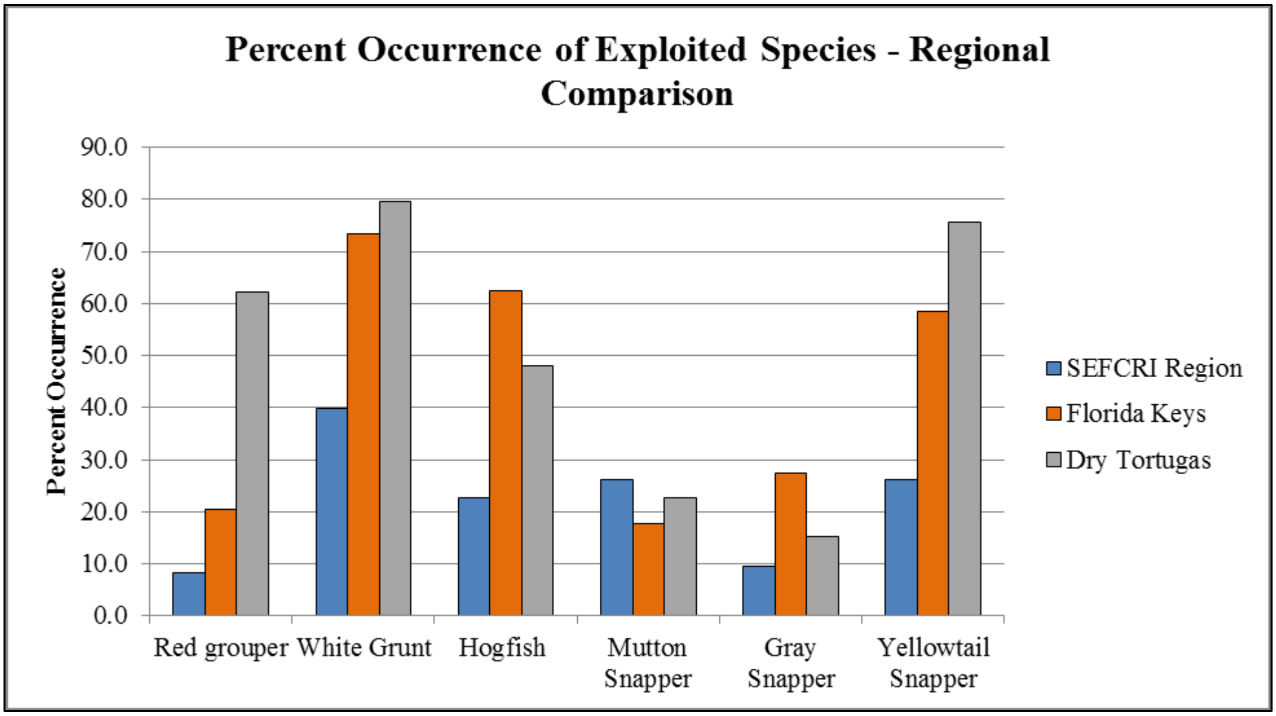

Figure 62. *Exploited species – comparison of SE Florida region to FL Keys and Dry Tortugas by percent occurrence ($\bar{P}$).*

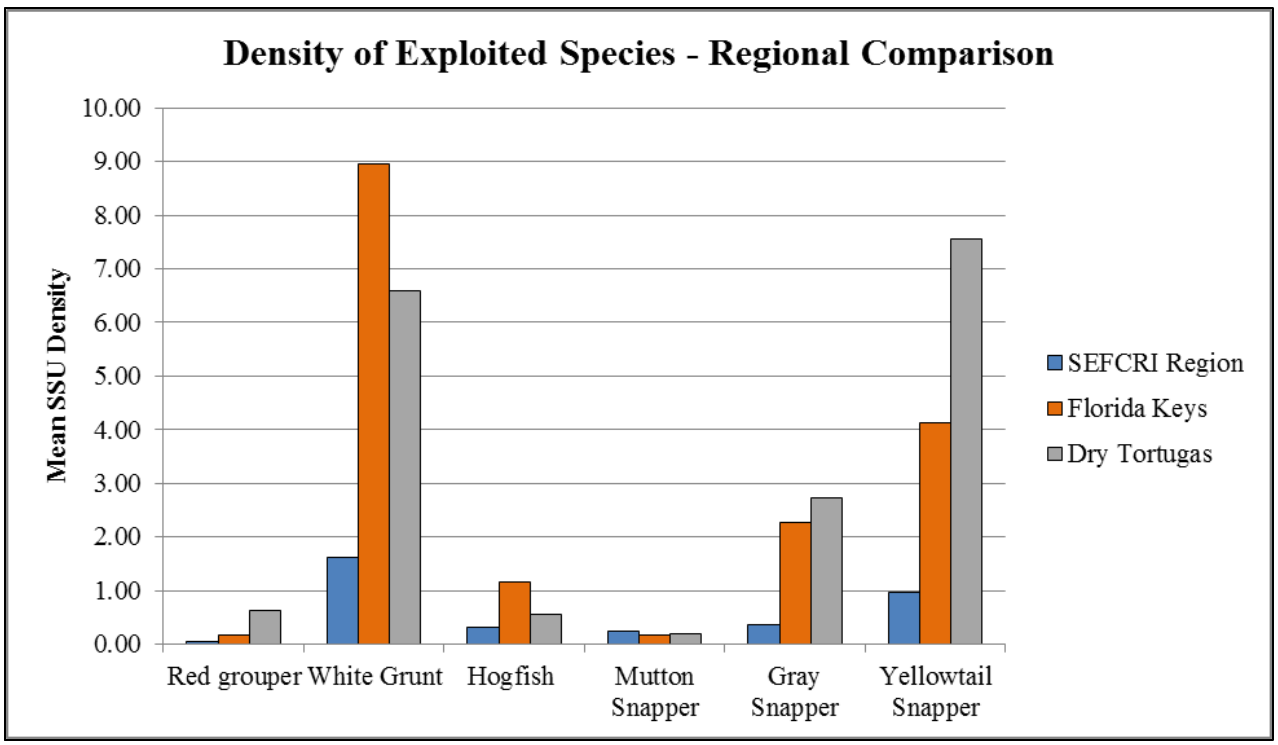

Figure 63. *Exploited species – comparison of SE Florida region to FL Keys and Dry Tortugas by mean (SSU) density ($\bar{D}$).*

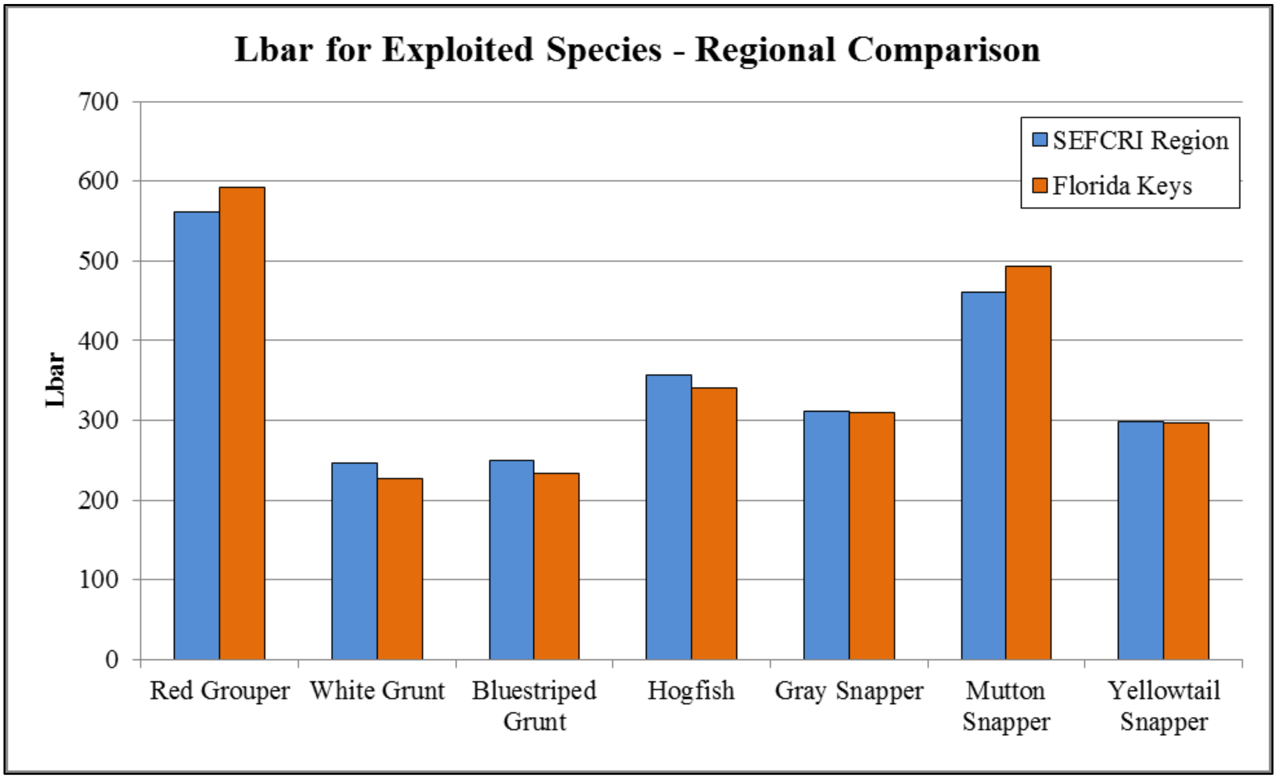

Figure 64. *Exploited species – comparison of SE Florida region to FL Keys by Lbar (FL Keys data from Ault et al., 2004).*

4.2. Sampling Effort and Allocation Performance

The 2012 sampling allocation was guided by the proportion of mapped habitats in the 100 x 100 m sampling frame, with the exception that all strata receive at least 5 sites and none are allocated more than 50 sites. This design had its advantages and disadvantages.

One potential problem with using the 100m PSU grid sampling frame to allocate sites is that it may not accurately represent the actual mapped habitat. The 100m PSU grid was assigned habitat values by the majority of habitat in that cell. For example, if a cell was 20% sand, 30% patch reef, and 50% Outer Reef, the cell was classified as Outer Reef. This method for classifying the PSU becomes especially problematic along habitat borders and for habitats that are small relative to the grid size (e.g. high slope reef edges, patch reefs), where it can drastically over or under estimate habitat extents. To investigate this further, the area of each habitat strata was calculated in GIS for the habitat map and the PSU grid. The results showed that the PSU grid overestimated the area of 24 habitat types by more than one km² (eleven 1 - 2 km², five $2 \leq 3$ km², four $3 \leq 4$ km², and four > 4 km²). The PSU grid also underestimated the area of Broward-Miami Low Slope Spur and Groove, Outer Reef, and Aggregated Patch Reef Deep by 1.2 km², 1.997 km², and 2.042 km² respectively. This comparison indicated that the area of many habitats is not well-represented in the PSU grid.

In terms of this study's design, however, the area of habitat was not as important as the habitat proportion. Since site allocations were made based on the proportion of each stratum, it was important that the PSU grid contain similar ratios of each habitat as the original habitat map. A comparison of habitat proportions between the habitat map and the PSU grid showed a similar distribution (Figure 65). The PSU grid had 89% (74/83) of the strata with less than 1% difference from the habitat map. The largest differences were with the North Palm Beach Deep Ridge Complex Low Slope, where the PSU grid had a proportion 5.4% less than the habitat map, and the Broward-Miami Colonized Pavement Shallow Low Slope, which was underestimated by 2.5%. However, these underestimations of habitat proportions did not affect the allocation because they were the two largest strata and were capped with a maximum of 50 sites. Thus the allocation of sites based on the proportion of strata in the PSU grid was very similar to an allocation using the habitat map.

In terms of the eight targeted fisheries species (*B. capriscus*, *E. morio*, *H. plumierii*, *H. sciurus*, *L. maximus*, *L. analis*, *L. griseus*, and *O. chrysurus*), the stratification seemed to perform well. One way to gauge performance is by plotting the average density of the species by the standard deviation. It is expected that low average density per strata will have a low standard deviation while high average density will have a high standard deviation. This was true in most cases for all eight species which helps substantiate the overall strategy sampling (Figure 66).

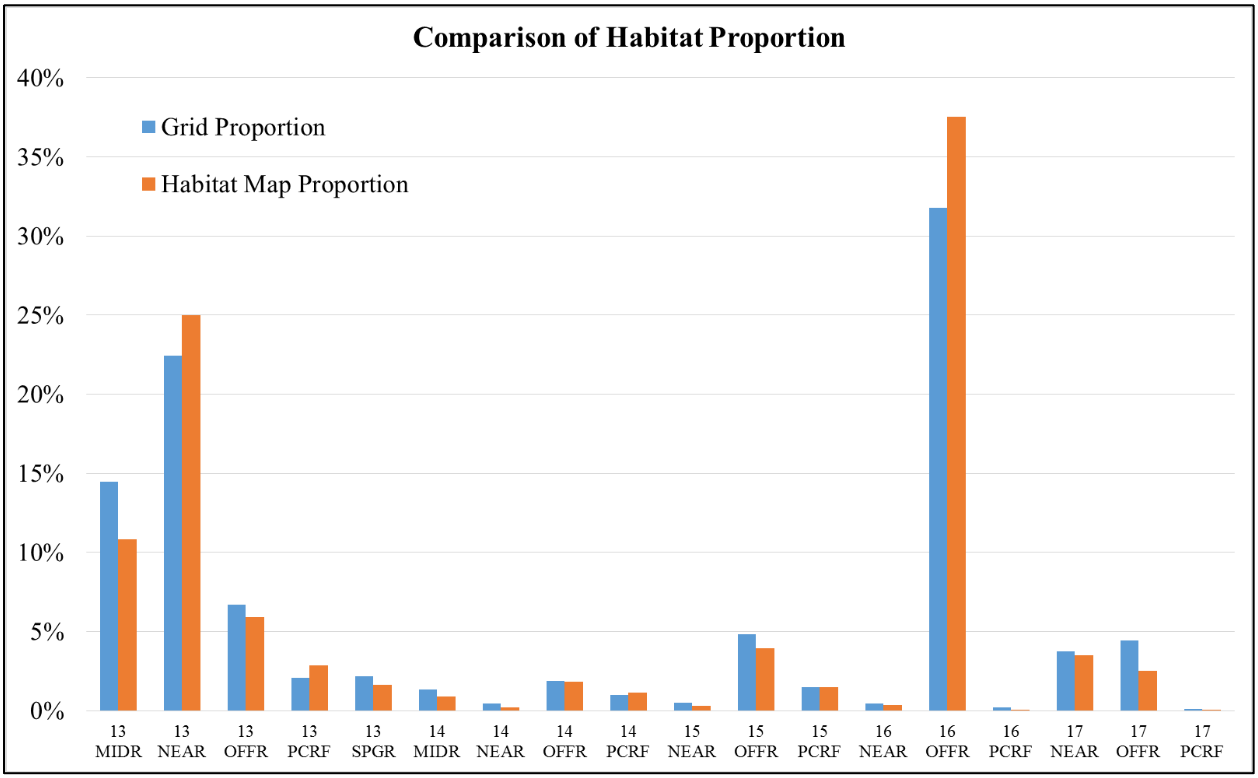

Figure 65. *A comparison of the habitat proportion in each stratum relative to the mapped domain. Blue is the percent area of the 100 m PSU grid and orange is the percent area of the map polygons.*

Of the 720 secondary sample units (SSU) allocated to strata, a total of 432 were completed in 2012 due to unanticipated funding delays compressing the field season and unforeseen logistical problems reducing the effort of local partners (Appendix 1). These issues were resolved in the 2013 and 2014 surveys. The incompletion of the total allocation in 2012 left large gaps in certain strata because strata were not targeted proportionally throughout the survey period. For example, 17 of the 100 allocated SSUs in the North Palm Beach Deep Ridge Complex Low Slope strata were surveyed. Figure 67 shows a map of the difference between the projected allocation and the actual surveyed sites by strata in 2012. High values (in oranges and red) indicate strata that were under surveyed and green values are strata that were over surveyed. Most under surveyed strata were in the northern regions (Martin and North Palm Beach), however, the high slope offshore strata in Broward-Miami and South Palm Beach were also under-sampled. These strata were not missed due to lack of effort, but rather shortcomings in the survey design. Because the high slope stratum does not dominate entire 100 m grid cells, it was often missed when finding the site. This was mostly because the site locations are determined by the center of the secondary sampling unit (one of four 50 m cells nested in the 100 m cell). When divers were deployed on a high slope target, they were not instructed to seek high slope, thus in many cases, the divers sampled lower relief features leaving a gap in the high slope surveys.

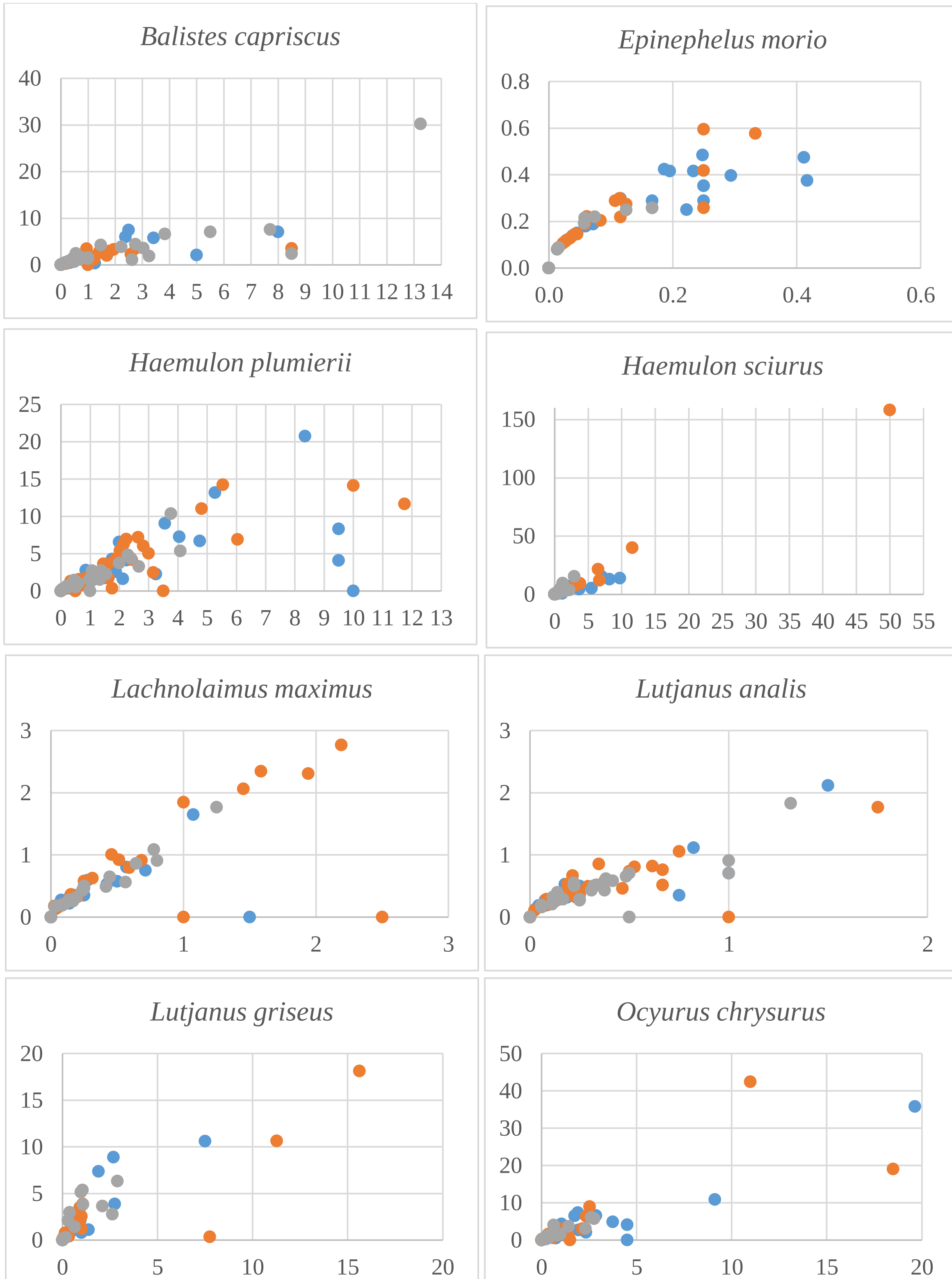

Figure 66. *Scatterplots of average mean density (x axis) versus standard deviation (y axis) by each strata for the eight key fisheries species targeted. A linear relationship is expected and indicates good site stratification and allocation.* Haemulon plumieriii *had the most variability in higher densities. Blue = 2012, Orange = 2013, and Gray = 2014.*

Several steps were taken during the 2013 site allocation process to help correct the 2012 site allocation problems. First, the 2013 site targets were divided into two groups based on the 2012 effort, called Core and Tier 2 sites. The same number of total sites (720) was projected to be the target for 2013. To prevent large gaps in strata if the groups do not meet their projection, 520 sites were randomly selected as Core sites based on the map strata proportions. Once all Core sites were completed by each group, they were given the Tier 2 sites to complete. This ensured that if total site projections were not met, at least a core set of data was complete for all strata, reducing regional habitat-specific surveying gaps. Appendix 4 contains maps of all 2013 Core, Tier 2, and actual survey sites.

As discussed above, a result of the gridded sampling array is that many times the targeted habitat does not span the entire 100 x 100 m cell. The site target coordinate is the geographic center of the randomly chosen cell. This becomes problematic when trying to hit specific habitats, especially high relief and patch reef sites. The second step to help correct for allocation problems for 2013 is that every secondary stage site target was evaluated in GIS. Each site was plotted and cross referenced by the habitat map, LIDAR bathymetry, and aerial photography (where possible) to see if the location of the point reflected the intended target. If they did not agree, the location was moved to the nearest area in the map that indicated the intended target strata. Thus high relief sites were moved to obvious areas of high relief in the bathymetry and sites that plotted away from the edges of habitats were moved inside.

The third correction for 2013 was that divers were instructed to find high slope sites when sampling those strata. In combination, these corrections facilitated the field operations and provided a better chance of the divers surveying the intended strata (Figure 68). The Nearshore habitats in Martin were not surveyed as much as planned, however most of the surveys in other habitats were much closer to the allocation targets than in 2012.

In 2014 the allocations were mostly within a small range of the targets (Figure 69). However the two largest habitats North Palm Beach Low Slope Deep Ridge Complex and Broward-Miami Low Slope Nearshore were considerably off. This was not from a lack of effort but rather a difference in the way rugosity/relief/slope was defined. In the map, high slope was defined by having a bathymetric slope >5°. In the fish surveys, rugosity/relief/slope was estimated by divers and gauged by the data analyst. Anything estimated over 0.3 m vertical relief was considered high. This discrepancy caused many of the sites mapped as low slope to be gauged as high slope by the divers. Consequently the allocations for high slope areas were much higher than targeted and vice versa.

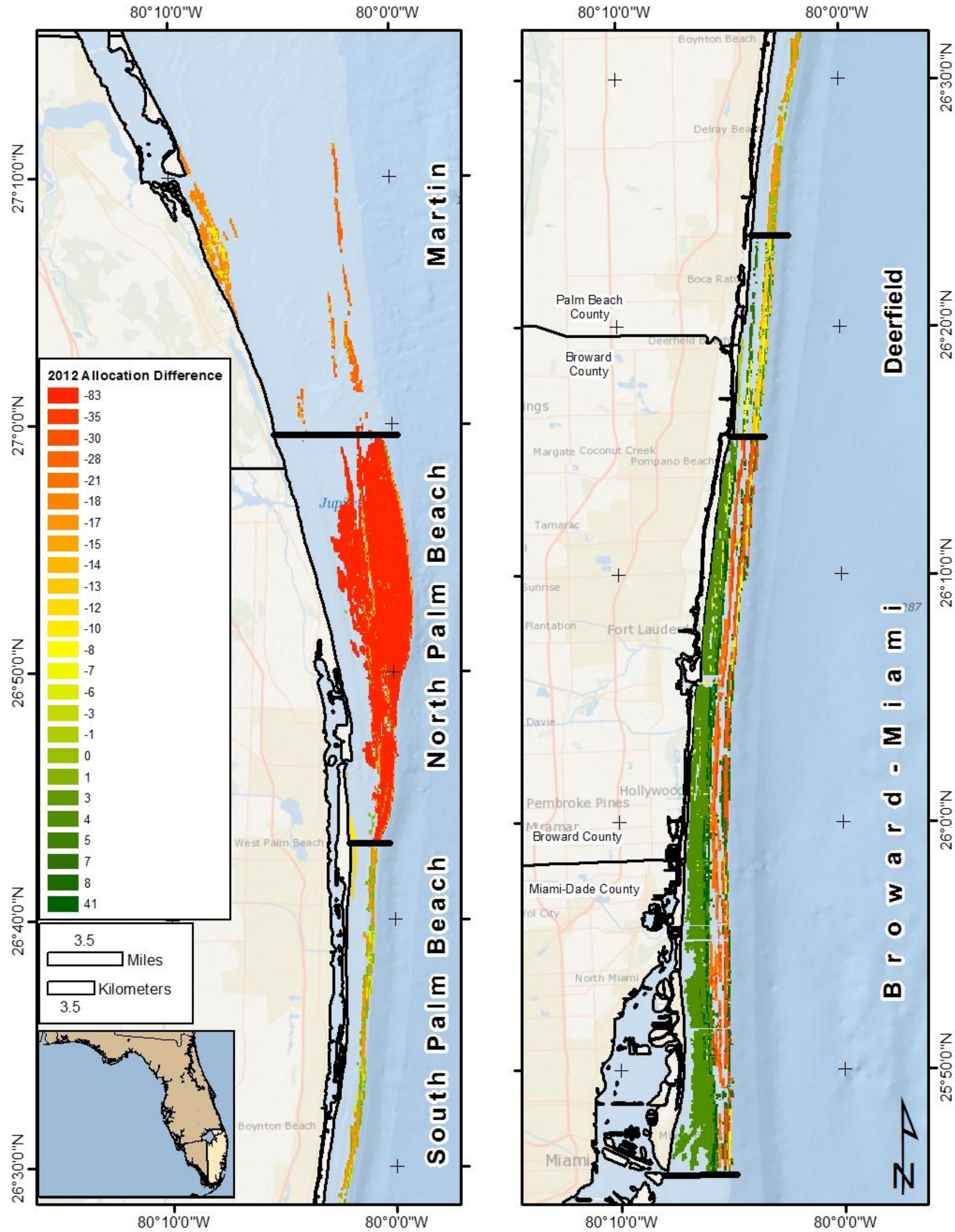

Figure 67. *Map showing the 2012 100 m grid strata symbolized by the difference in projected allocation v. realized from Table 2. Most extreme gaps were in the northern regions. Red values are lower than projected and green are higher.*

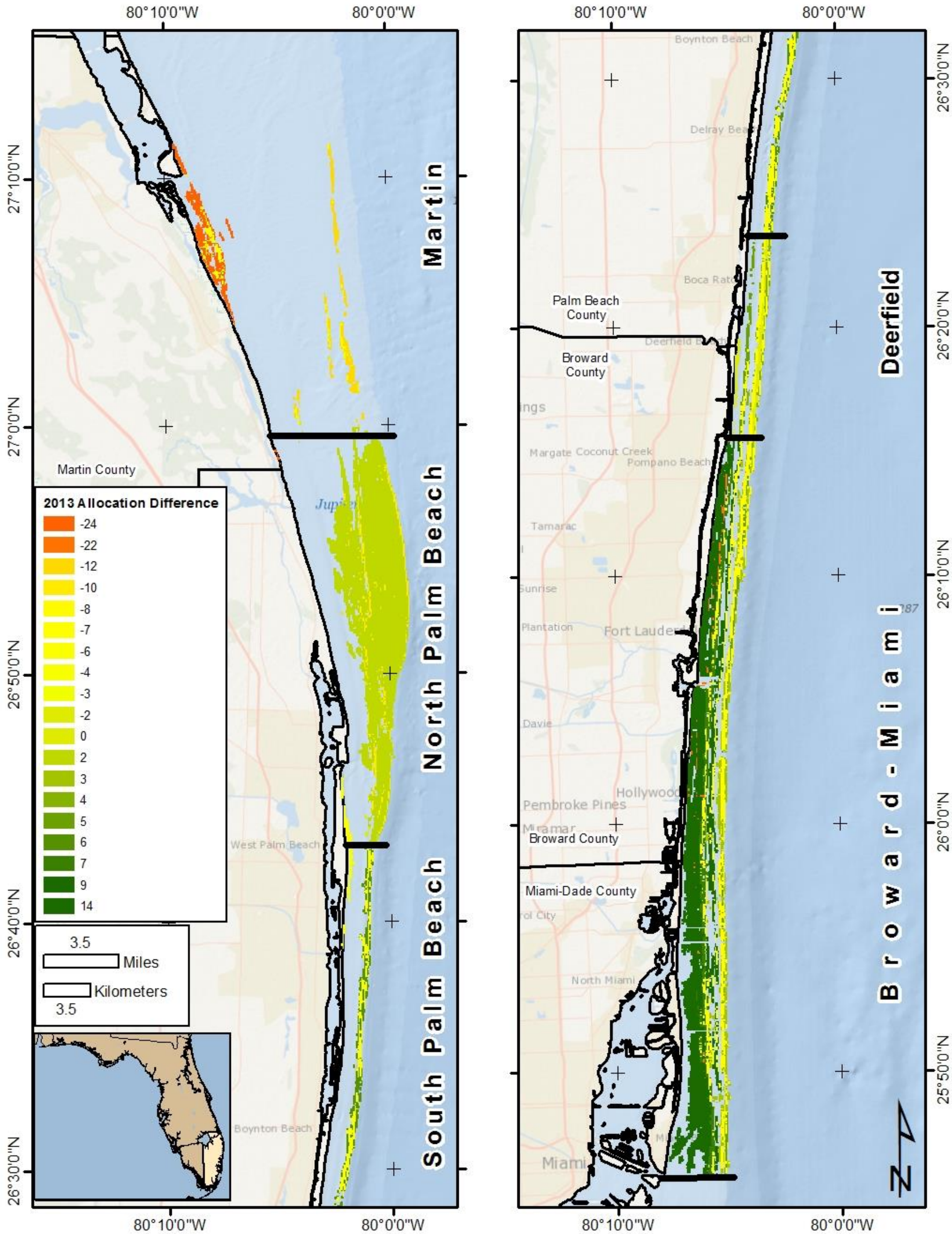

Figure 68. *Map showing the 2013 100 m grid strata symbolized by the difference in projected allocation v. realized from Table 2. Many gaps were corrected in 2013. A large deficit in survey coverage remained in Nearshore Martin habitats. Red values are fewer surveys than projected and green are higher.*

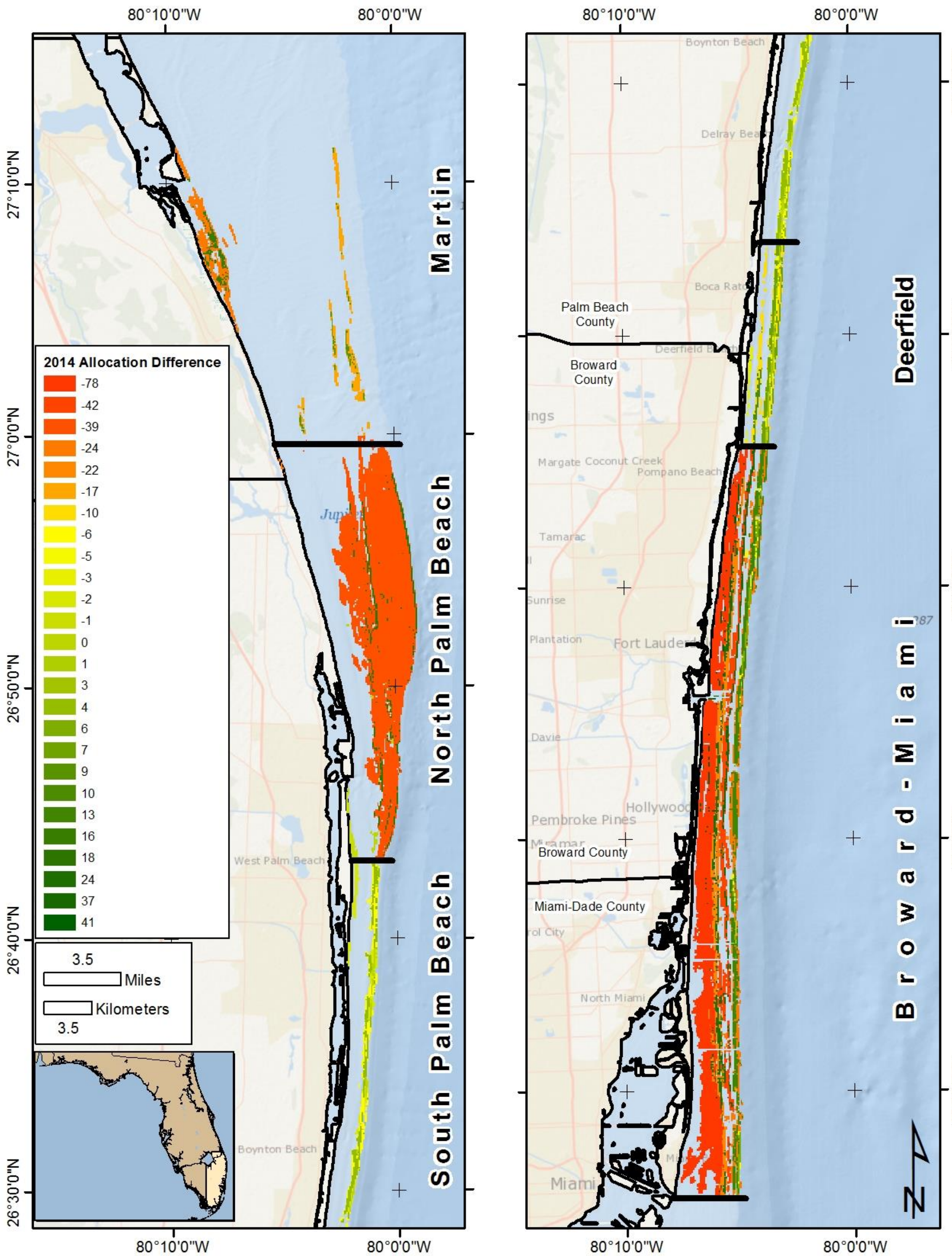

Figure 69. *Map showing the 2014 100 m grid strata symbolized by the difference in projected allocation v. realized from Table 2. Red values are fewer surveys than projected and green are higher. The two areas with large deficits were low slope habitats that were under-surveyed because the sites were higher relief than the map depicted.*

5. SUMMARY AND CONCLUSIONS

Clearly, an important first step in resource management is determining the state of that resource. This report provides a synoptic view of a large database which provides summary statistics and graphs of reef fish richness and abundance, assemblage distribution, and select species distribution on the northern portion of the Florida Reef Tract. The dataset provides a baseline for these variables which is critical information for the local management of fishery resources now and in the future. Further, the dataset provides the opportunity for further mining to examine species and assemblage correlations with a host of abiotic and biotic variables. Thus, from both management and ecological sciences perspectives these data are a valuable resource. It is already clear there are significant differences in the current geographic distribution of the reef fishes in southeast FL; there are interacting strata and latitude differences in total abundance, species, sizes, and assemblages within the northern portion of the FRT.

However, we caution against drawing premature conclusions from a limited dataset. Many factors can contribute to differences in community structure and abundance of reef fishes. Reef fish assemblages are influenced by a combination of abiotic and biotic variables, such as: reef morphology, water chemistry, temperature, depth, current regimes, terrestrial influences (i.e. runoff, sedimentation, nutrient levels), extreme weather events (hurricanes, cold snaps), large scale climate changes, benthic community composition, stochastic settlement and recruitment dynamics (i.e. larval supply, predation, competition, etc.), and changes in biogeographic distribution of species. In addition, anthropogenic impacts (pollution, construction) and associated management practices (beach nourishment, fishing regulations) are an influential presence in the coastal marine environment. Many fish populations fluctuate on seasonal or multi-year scales in response to a combination of the aforementioned variables. Because population levels can fluctuate greatly from year to year, understanding of how these biotic and abiotic variables interact with one another and change in response to management practices will be improved with a long-term dataset. Further, because effective management of fish resources demands effective monitoring of populations of early life-stages and their habitats we recommend this is taken into account in future surveys.

Comparing data from the northern portion of the FRT (this study) with previously published data (Smith et al., 2011) shows a pattern of increasing percent occurrence and density, and similar Lbar, for most but not all, target species from southeast Florida down through the Florida Keys and into the Dry Tortugas. Likewise this comparison leads to the impression that many species of fisheries interest are overfished in the northern portion of the FRT as they are in the Keys. This dataset then does not represent a pristine environment that provides a target for preservation. Rather, the dataset provides a picture of an environment that has already experienced substantial anthropogenic impact; it provides a critical baseline for management strategies aimed at improvement.

The North/South pattern of lower numbers of exploited and non-target species in the northern portion of the FRT is not clear (Appendix 6). In some cases this may indicate some substrate associated with the species is more or less sporadically distributed in the north than in the south. For example, staghorn coral and mangroves, which are associated with Threespot Damselfish and Gray Snapper and Great Barracuda abundances, respectively, are sparsely available or highly localized in the northern portion of the FRT (Nagelkerken et al., 2000; Precht et al., 2010). In other cases, the northern portion of the FRT may simply represent the most northern or southern part of a species' range (i.e. Gag, Black, Nassau Groupers). However, some populations appear egregiously low in comparison to the southern tracts (specifically: Red Grouper, Gray Snapper and Great Barracuda) and these should be targeted for immediate management attention.

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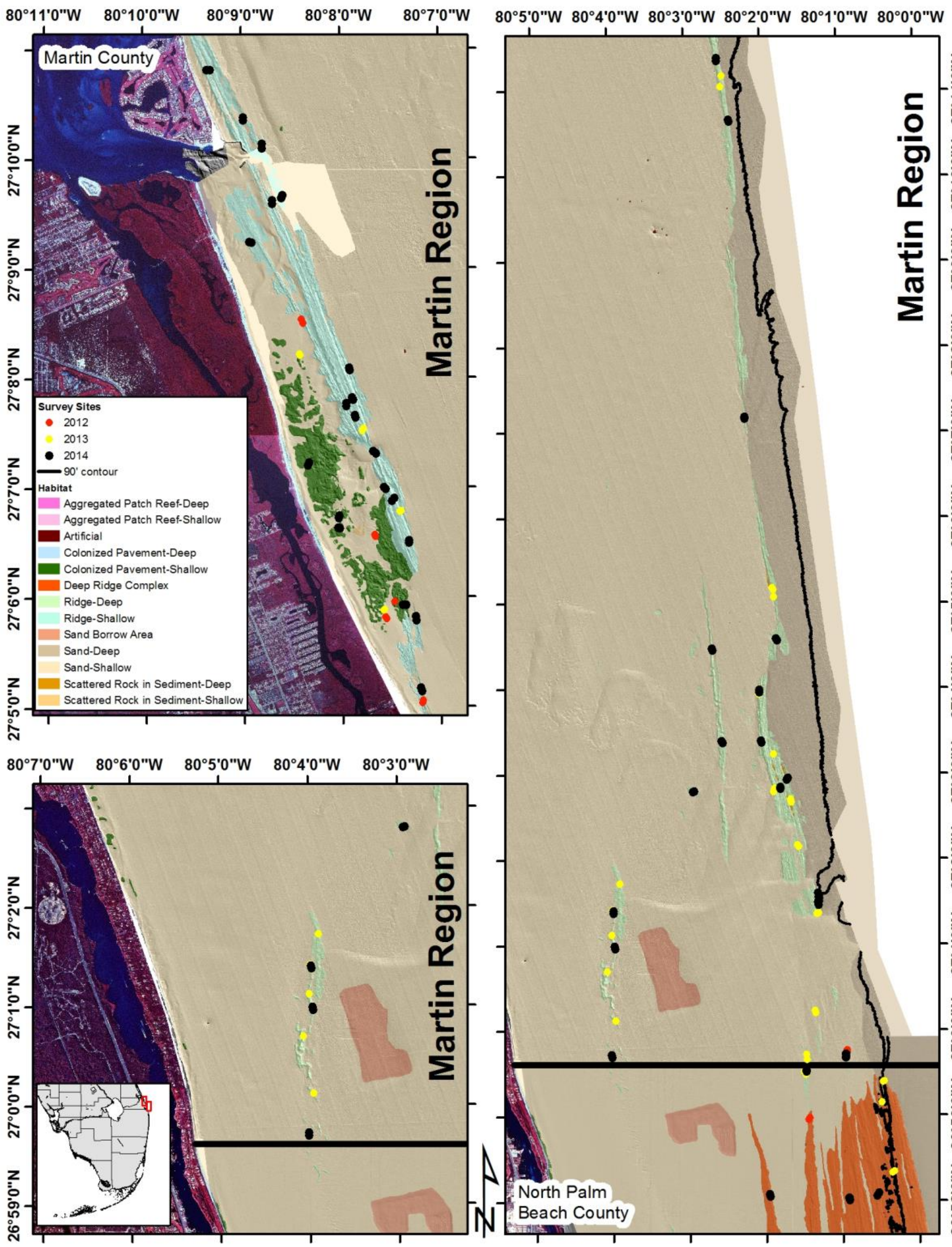
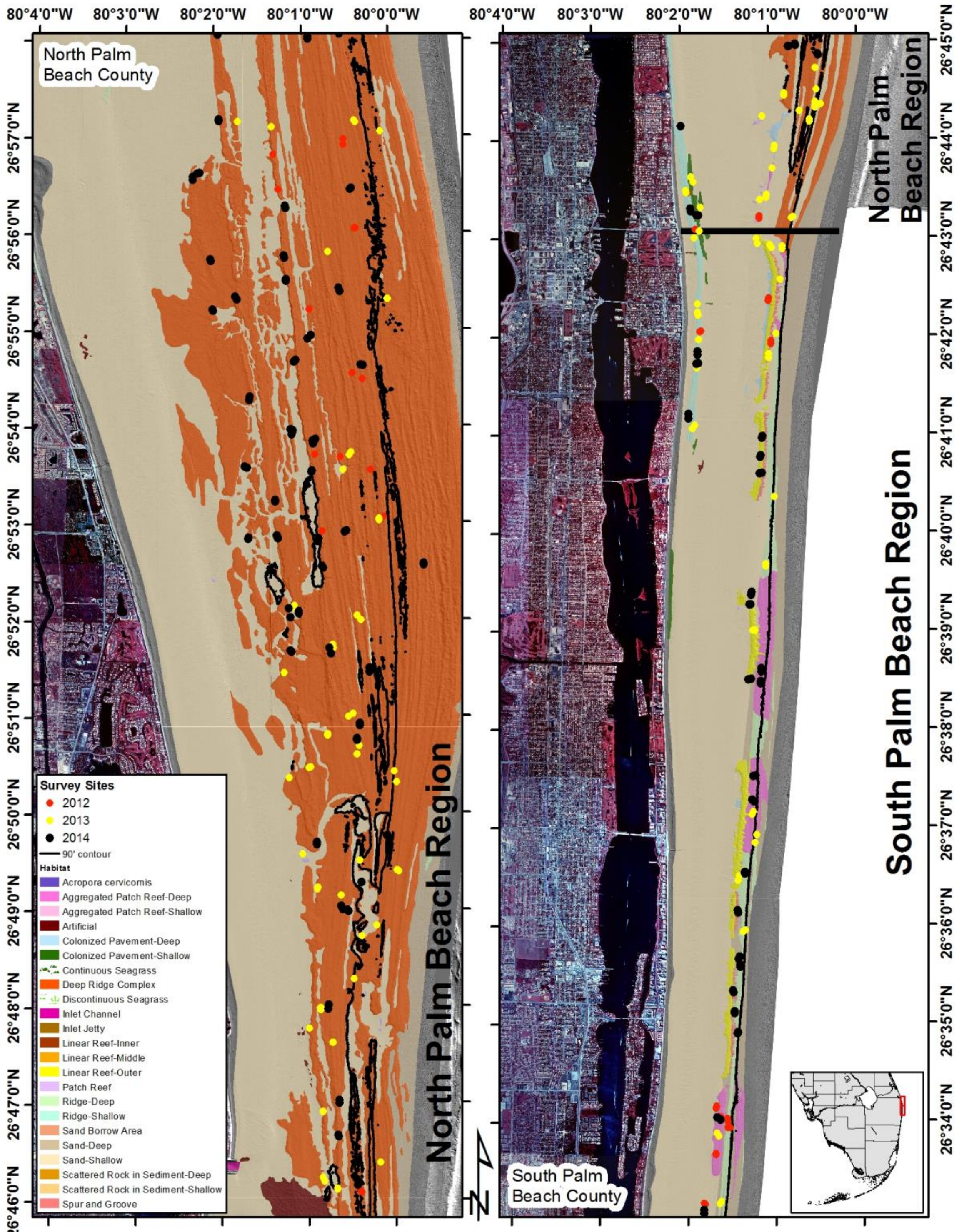
7. APPENDICES

Appendix 1. Effort allocation for targeted secondary sampling unit (SSU) locations and realized sampling locations by strata for each year. Strata: Subregion, Habitat, Slope.

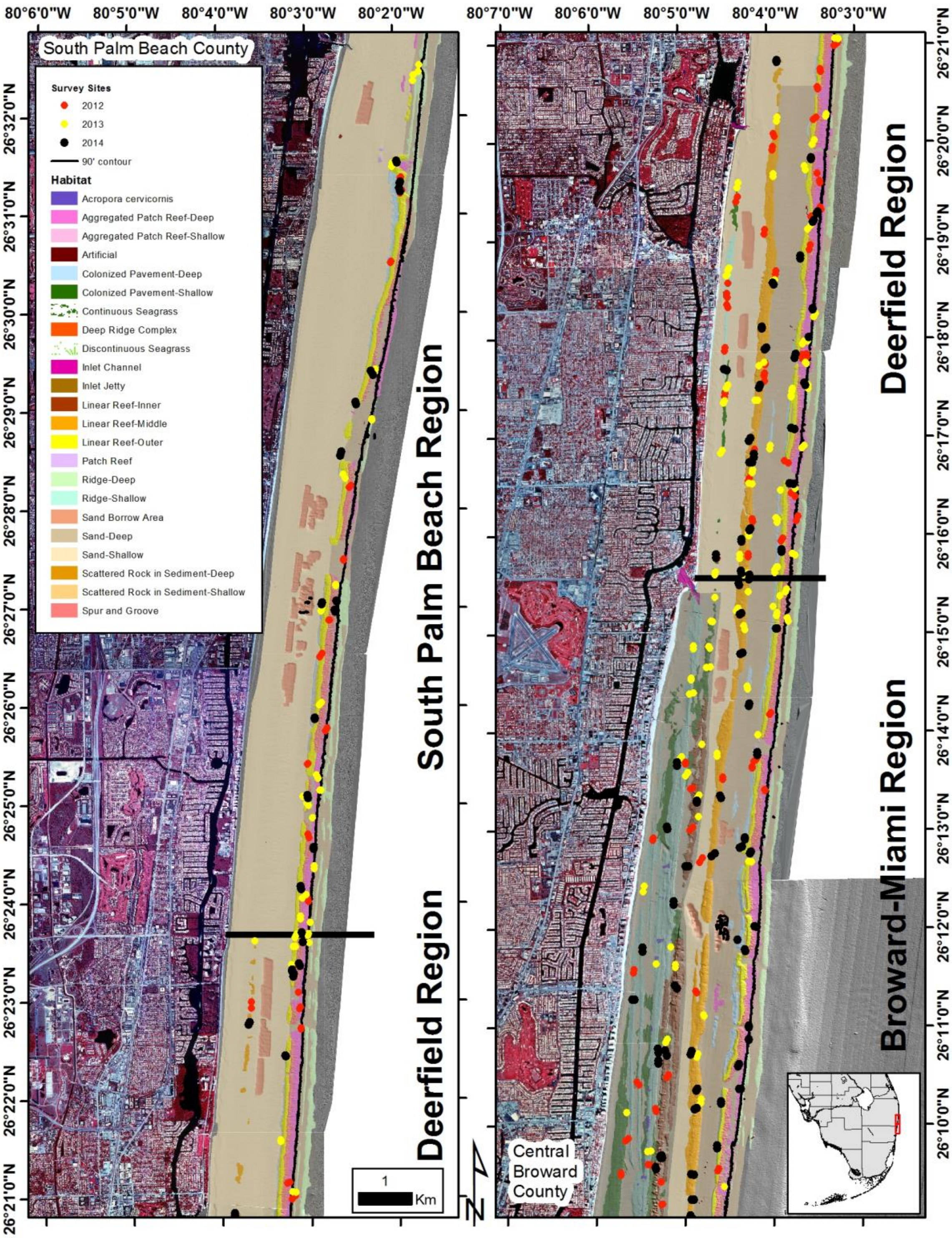
	2012		2013		2014		Grand Total	
Strata	**Target**	**Realized**	**Target**	**Realized**	**Target**	**Realized**	**Target**	**Realized**
Broward-Miami INNR High		4	20	12	20	44	40	60
Broward-Miami INNR Low		41	26	33	30	8	56	82
Broward-Miami MIDR High	36	1	20	13	26	63	82	77
Broward-Miami MIDR Low	72	51	26	35	50	8	148	94
Broward-Miami NEAR High	14	4	30	8	20	61	64	73
Broward-Miami NEAR Low	100	104	100	114	100	22	300	240
Broward-Miami OFFR High	44	14	60	52	52	65	156	131
Broward-Miami OFFR Low	26	34	26	29	28	4	80	67
Broward-Miami PTDP High	14	6	14	19	8	14	36	39
Broward-Miami PTDP Low	10	7	10	3	6	1	26	11
Broward-Miami PTSH N/D		11		2	6	2	6	15
Deerfield MIDR High	14	6	14	7	16	26	44	39
Deerfield MIDR Low	10	17	10	15	10		30	32
Deerfield NEAR High	14		14			1	28	1
Deerfield NEAR Low	16	13	20	14	6	3	42	30
Deerfield OFFR High	10	3	16	12	14	21	40	36
Deerfield OFFR Low	14	15	14	20	10		38	35
Deerfield PTDP High	10	7	10	14	6	9	26	30
Deerfield PTDP Low		13		8	6	1	6	22
Deerfield PTSH N/D		1						1
South Palm Beach NEAR High				2		2		4
South Palm Beach NEAR Low	14	2	14	10	6	4	34	16
South Palm Beach OFFR High	28	11	28	22	30	34	86	67
South Palm Beach OFFR Low	16	17	14	20	18	12	48	49
South Palm Beach PTDP High			14	6	6	6	20	12
South Palm Beach PTDP Low	10	4	10	16	6	4	26	24
South Palm Beach PTSH N/D	14	6		2	4	8	18	16
North Palm Beach DPRC High	18	3	18	8	20	38	56	49
North Palm Beach DPRC Low	100	17	76	78	100	61	276	156
North Palm Beach NEAR Low	14	4	14	8	6	5	34	17
North Palm Beach OFFR Low				2				2
North Palm Beach PTDP High			4	2			4	2
North Palm Beach PTDP Low			6	6			6	6
North Palm Beach PTSH N/D	10	2		2			10	4
Martin DPRC High				4		4		8
Martin DPRC Low		2		4				6
Martin NEAR High	14	4	14	6	20	36	48	46
Martin NEAR Low	24	6	24		30	6	78	12
Martin PTSH N/D	10		10	2			20	2
Martin RGDP High	14		14	11	20	29	48	40
Martin RGDP Low	30	2	30	18	20	3	80	23
Total	720	432	720	639	700	605	2140	1676

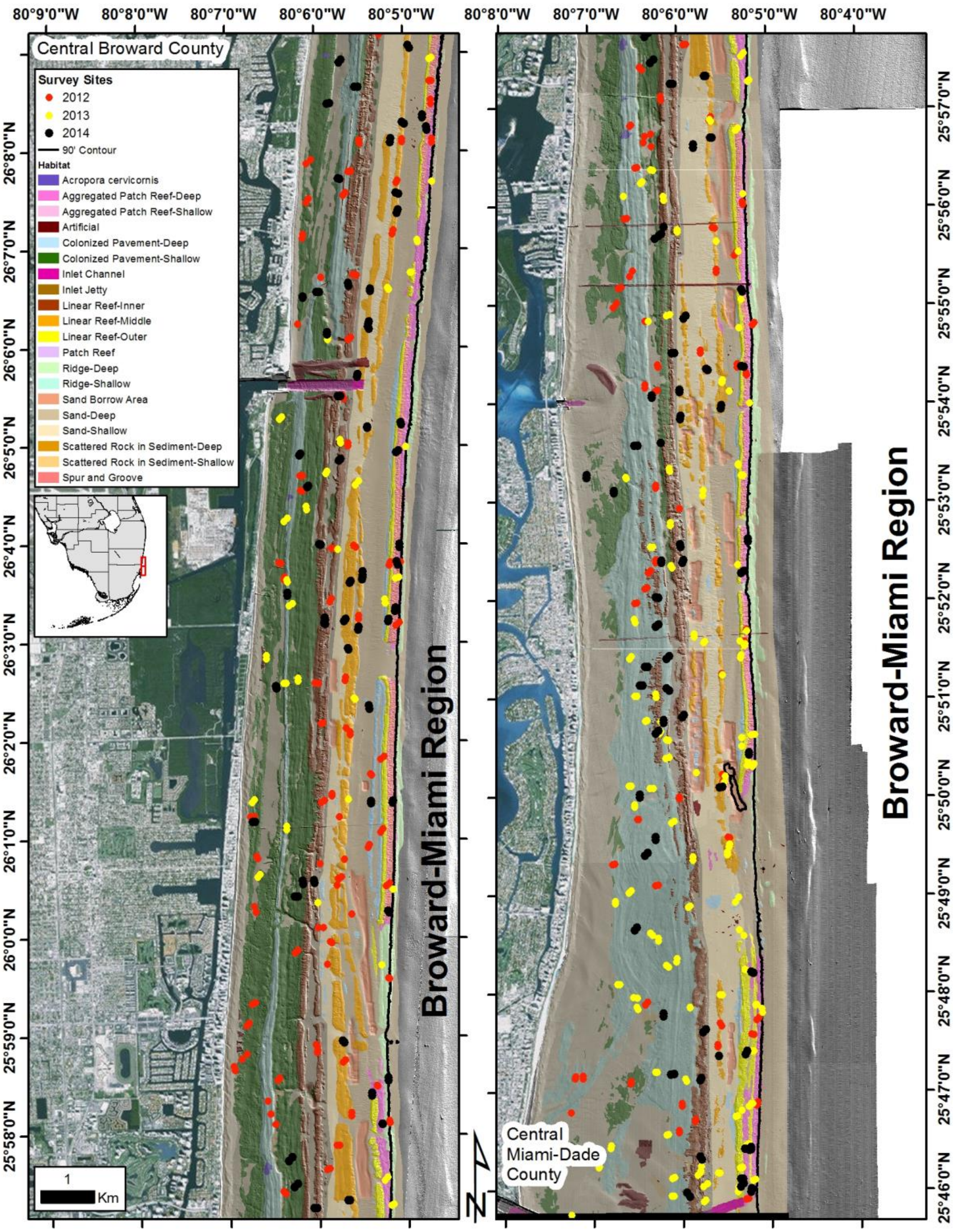
Appendix 2. Site Maps of actual survey locations from the combined 2012-2014 period. Red, Yellow, and Black points indicate sites sampled in 2012, 2013, and 2014, respectively.



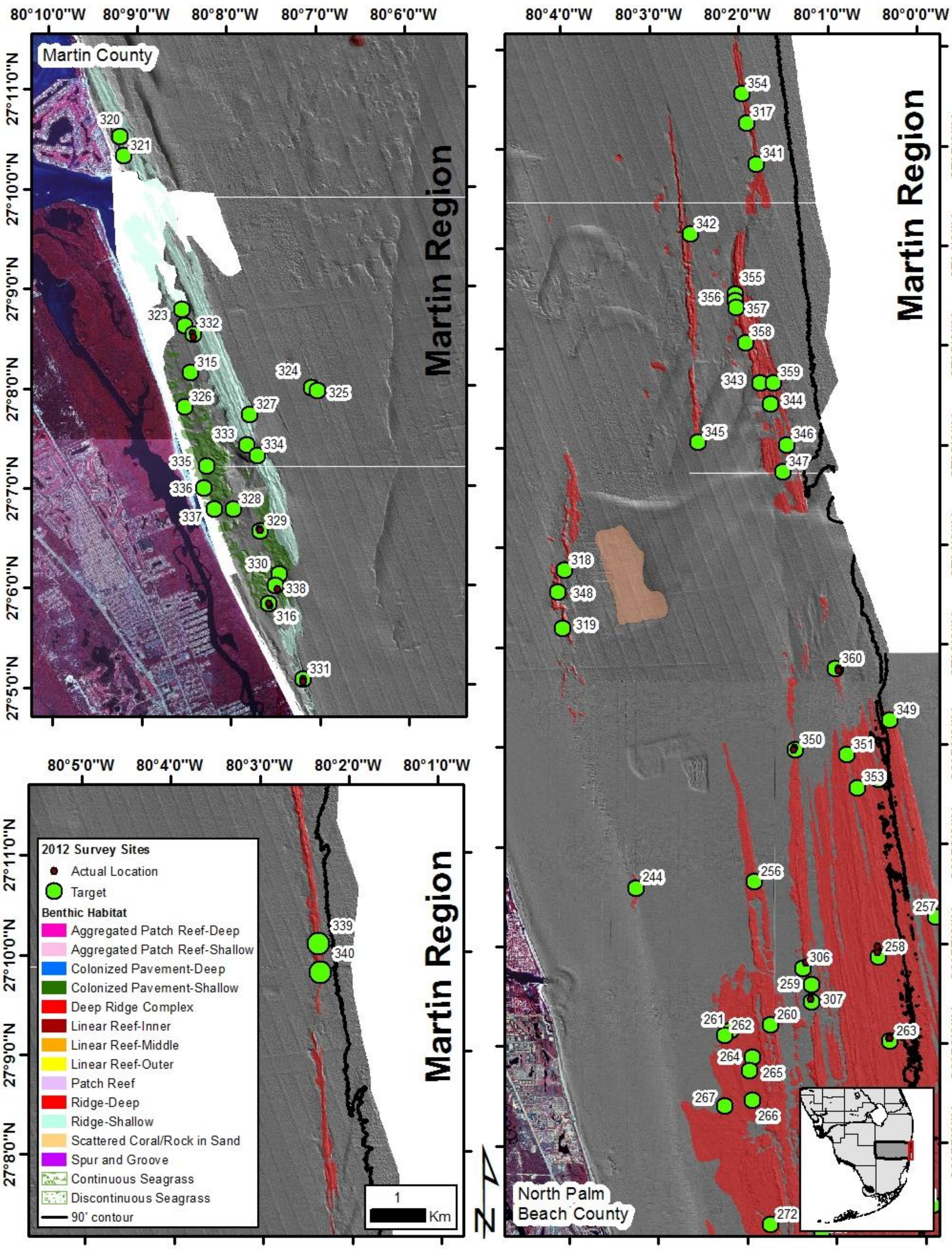


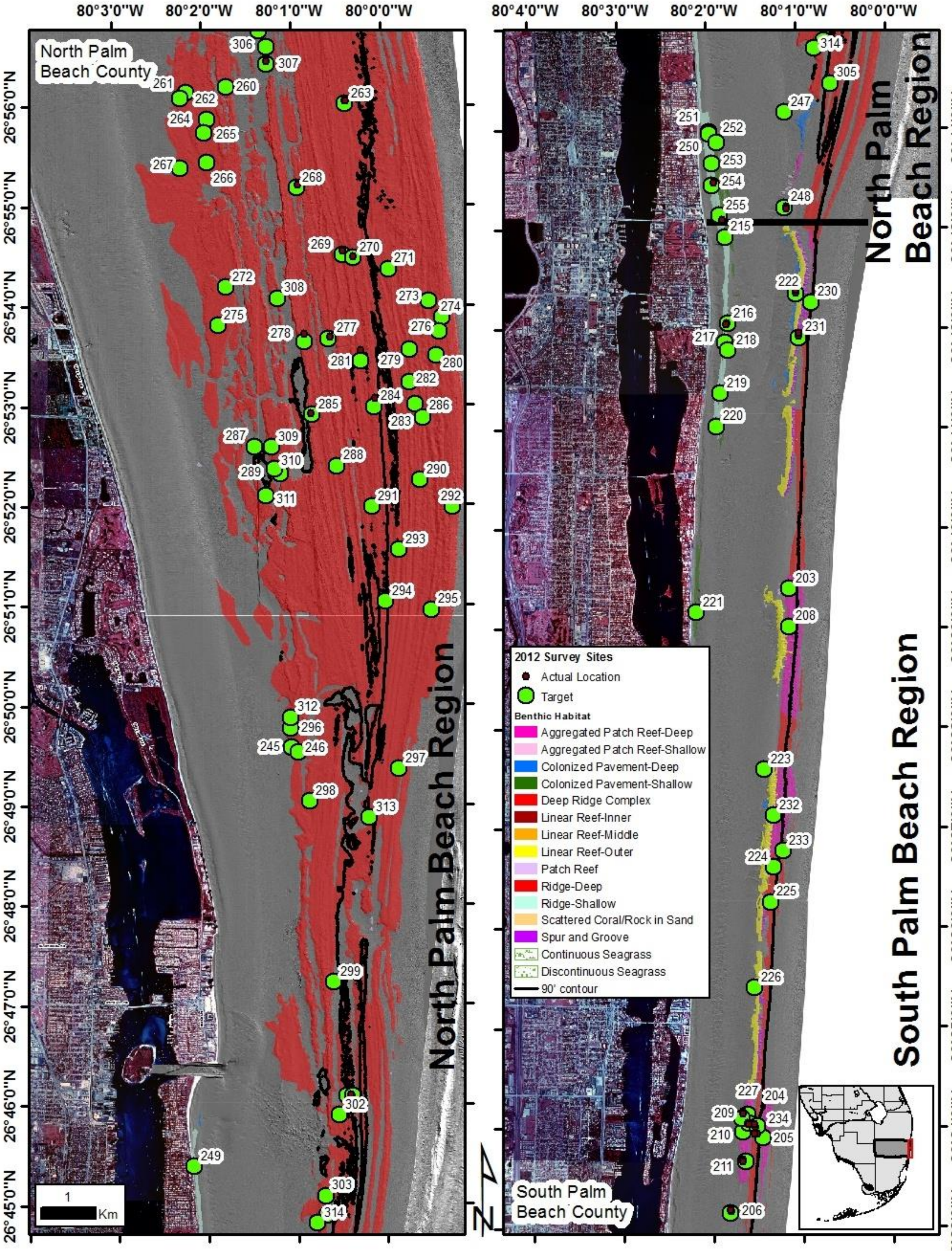
80°4'0"W
80°3'0"W
80°2'0"W
80°1'0"W
80°0'0"W
26°57'0"N
26°56'0"N
26°55'0"N
26°54'0"N
26°53'0"N
26°52'0"N
26°51'0"N
26°50'0"N
26°49'0"N
26°48'0"N
26°47'0"N
26°46'0"N
26°45'0"N
26°44'0"N
26°43'0"N
26°42'0"N
26°41'0"N
26°40'0"N
26°39'0"N
26°38'0"N
26°37'0"N
26°36'0"N
26°35'0"N
26°34'0"N
North Palm Beach County
South Palm Beach County
North Palm Beach Region
South Palm Beach Region
N
Survey Sites
2012
2013
2014
90' contour
Habitat
Acropora cervicornis
Aggregated Patch Reef-Deep
Aggregated Patch Reef-Shallow
Artificial
Colonized Pavement-Deep
Colonized Pavement-Shallow
Continuous Seagrass
Deep Ridge Complex
Discontinuous Seagrass
Inlet Channel
Inlet Jetty
Linear Reef-Inner
Linear Reef-Middle
Linear Reef-Outer
Patch Reef
Ridge-Deep
Ridge-Shallow
Sand Borrow Area
Sand-Deep
Sand-Shallow
Scattered Rock in Sediment-Deep
Scattered Rock in Sediment-Shallow
Spur and Groove

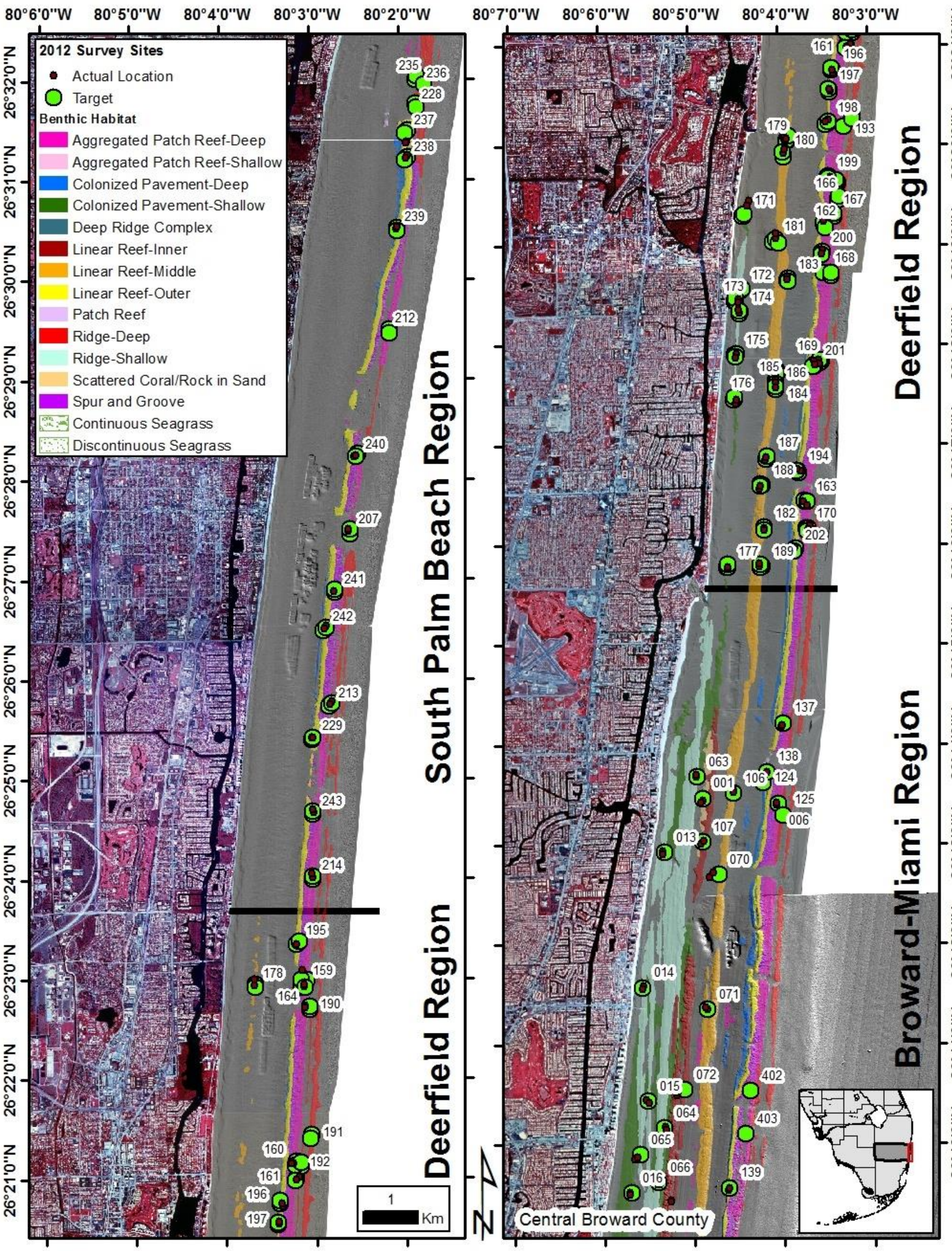

South Palm Beach County
Survey Sites
2012
2013
2014
90' contour
Habitat
Acropora cervicornis
Aggregated Patch Reef-Deep
Aggregated Patch Reef-Shallow
Artificial
Colonized Pavement-Deep
Colonized Pavement-Shallow
Continuous Seagrass
Deep Ridge Complex
Discontinuous Seagrass
Inlet Channel
Inlet Jetty
Linear Reef-Inner
Linear Reef-Middle
Linear Reef-Outer
Patch Reef
Ridge-Deep
Ridge-Shallow
Sand Borrow Area
Sand-Deep
Sand-Shallow
Scattered Rock in Sediment-Deep
Scattered Rock in Sediment-Shallow
Spur and Groove
South Palm Beach Region
Deerfield Region
Broward-Miami Region
Central Broward County
1 Km
N
80°6'0"W
80°5'0"W
80°4'0"W
80°3'0"W
80°2'0"W
80°7'0"W
26°32'0"N
26°31'0"N
26°30'0"N
26°29'0"N
26°28'0"N
26°27'0"N
26°26'0"N
26°25'0"N
26°24'0"N
26°23'0"N
26°22'0"N
26°21'0"N
26°20'0"N
26°19'0"N
26°18'0"N
26°17'0"N
26°16'0"N
26°15'0"N
26°14'0"N
26°13'0"N
26°12'0"N
26°11'0"N
26°10'0"N

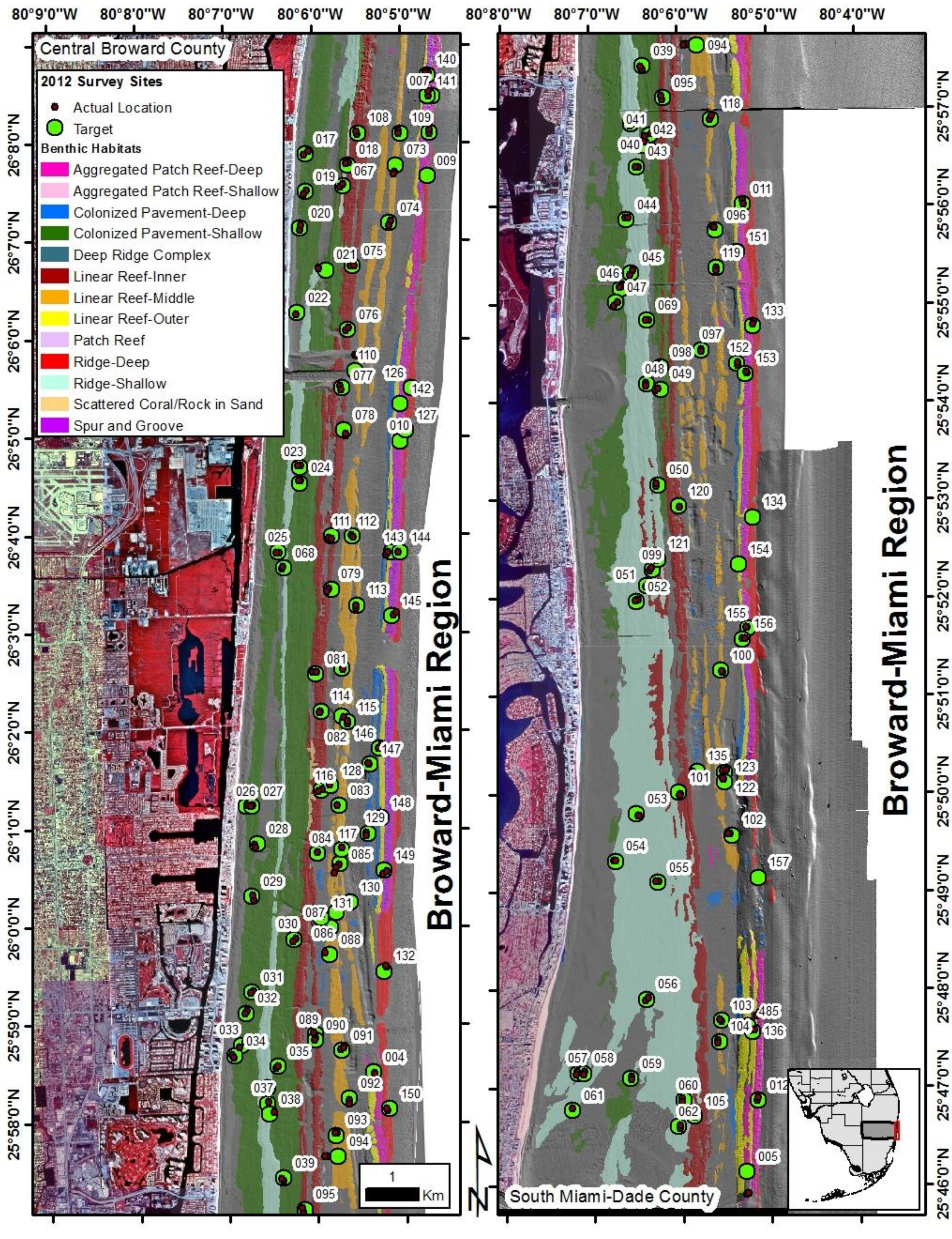

Central Broward County
Survey Sites
2012
2013
2014
90' Contour
Habitat
Acropora cervicornis
Aggregated Patch Reef-Deep
Aggregated Patch Reef-Shallow
Artificial
Colonized Pavement-Deep
Colonized Pavement-Shallow
Inlet Channel
Inlet Jetty
Linear Reef-Inner
Linear Reef-Middle
Linear Reef-Outer
Patch Reef
Ridge-Deep
Ridge-Shallow
Sand Borrow Area
Sand-Deep
Sand-Shallow
Scattered Rock in Sediment-Deep
Scattered Rock in Sediment-Shallow
Spur and Groove
Broward-Miami Region
Broward-Miami Region
Central Miami-Dade County
1
Km
N
80°9'0"W
80°8'0"W
80°7'0"W
80°6'0"W
80°5'0"W
80°8'0"W
80°7'0"W
80°6'0"W
80°5'0"W
80°4'0"W
26°8'0"N
26°7'0"N
26°6'0"N
26°5'0"N
26°4'0"N
26°3'0"N
26°2'0"N
26°1'0"N
26°0'0"N
25°59'0"N
25°58'0"N
25°57'0"N
25°56'0"N
25°55'0"N
25°54'0"N
25°53'0"N
25°52'0"N
25°51'0"N
25°50'0"N
25°49'0"N
25°48'0"N
25°47'0"N
25°46'0"N

Appendix 3. 2012 site maps. Green indicates Target Site and small points indicate actual survey locations. Target sites without corresponding "actual" sites were not surveyed.



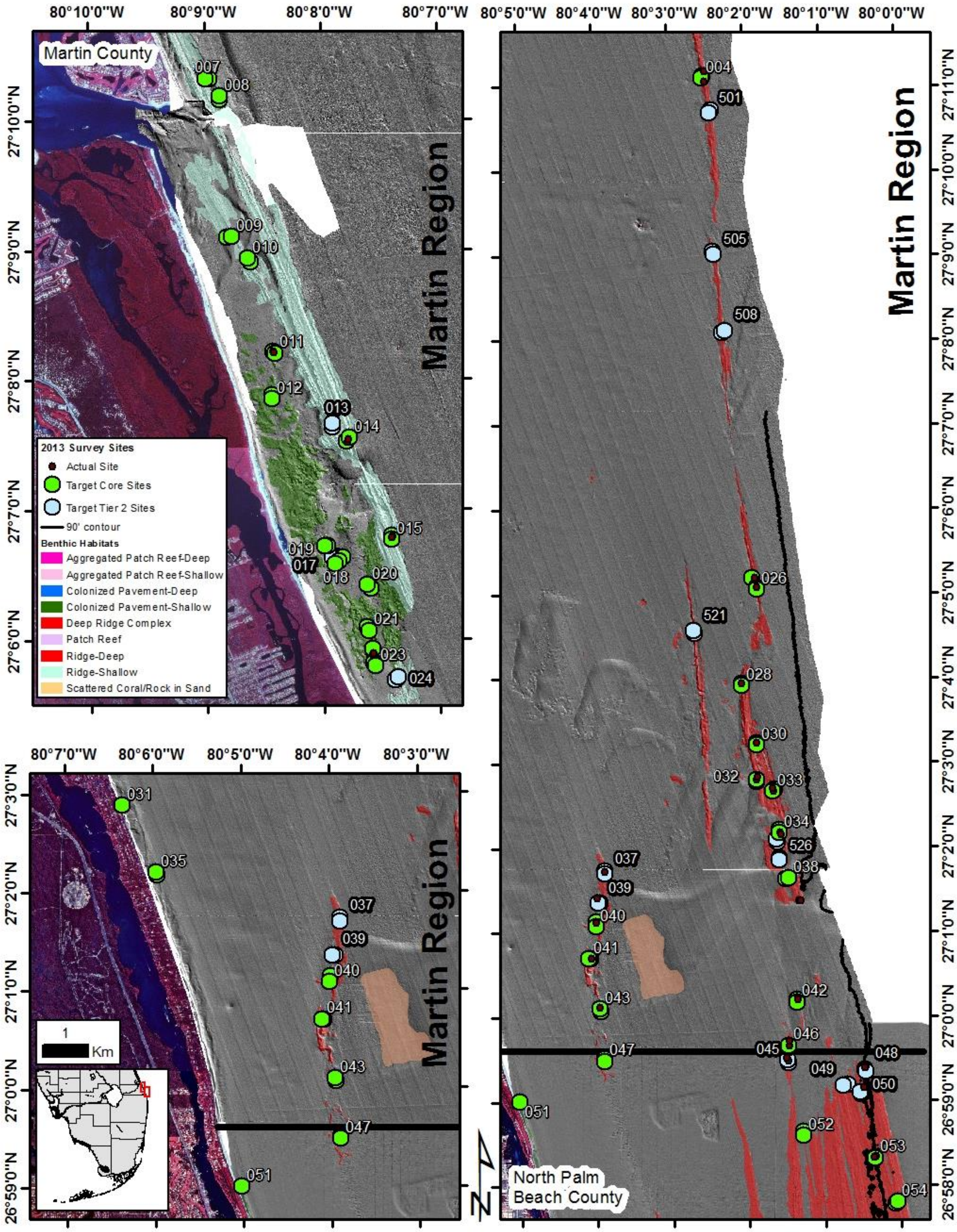

North Palm Beach County
North Palm Beach Region
South Palm Beach County
South Palm Beach Region
2012 Survey Sites
Actual Location
Target
Benthic Habitat
Aggregated Patch Reef-Deep
Aggregated Patch Reef-Shallow
Colonized Pavement-Deep
Colonized Pavement-Shallow
Deep Ridge Complex
Linear Reef-Inner
Linear Reef-Middle
Linear Reef-Outer
Patch Reef
Ridge-Deep
Ridge-Shallow
Scattered Coral/Rock in Sand
Spur and Groove
Continuous Seagrass
Discontinuous Seagrass
90' contour
1 Km
N

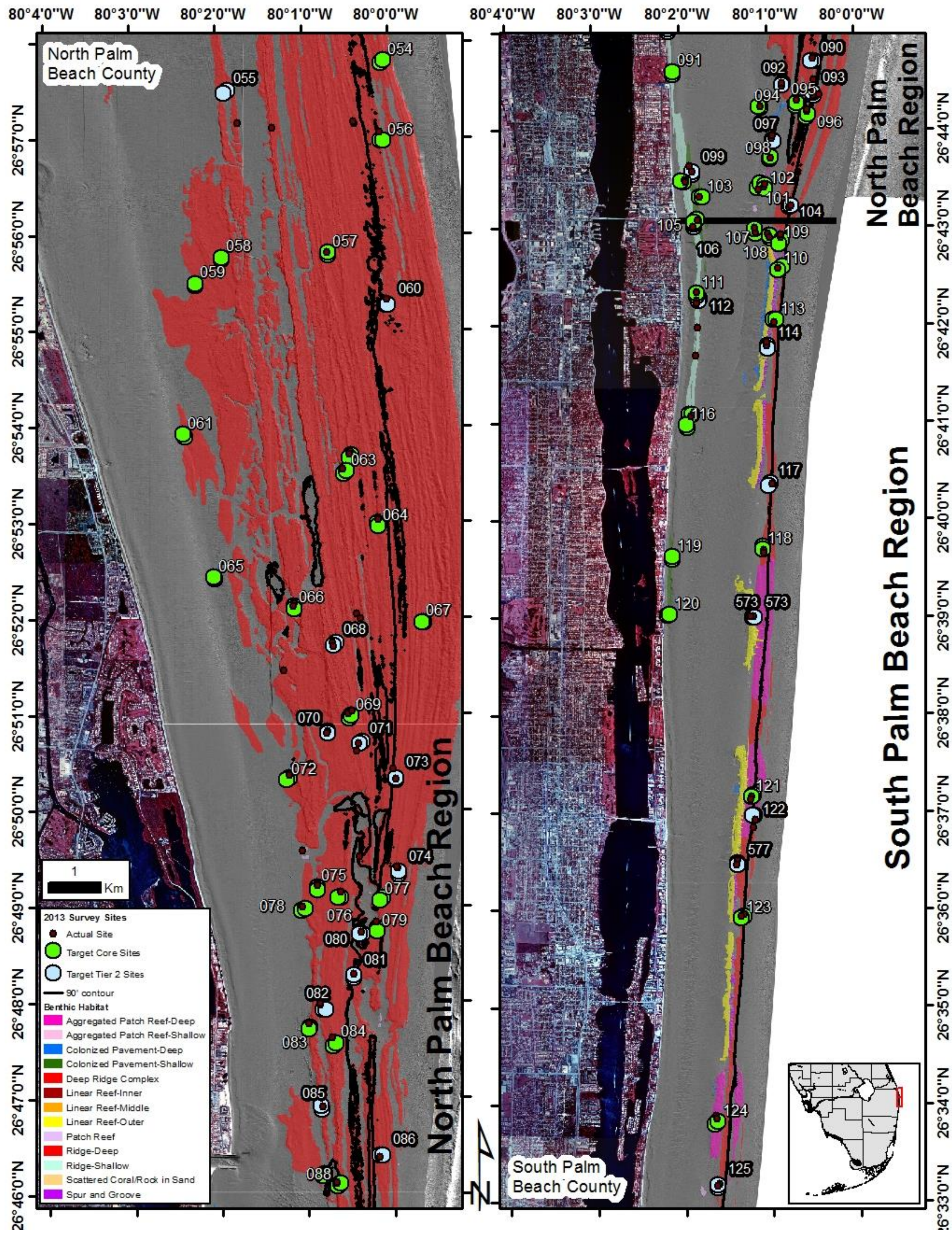

2012 Survey Sites
Actual Location
Target
Benthic Habitat
Aggregated Patch Reef-Deep
Aggregated Patch Reef-Shallow
Colonized Pavement-Deep
Colonized Pavement-Shallow
Deep Ridge Complex
Linear Reef-Inner
Linear Reef-Middle
Linear Reef-Outer
Patch Reef
Ridge-Deep
Ridge-Shallow
Scattered Coral/Rock in Sand
Spur and Groove
Continuous Seagrass
Discontinuous Seagrass
South Palm Beach Region
Deerfield Region
Broward-Miami Region
Central Broward County
1
Km
N
80°6'0"W
80°5'0"W
80°4'0"W
80°3'0"W
80°2'0"W
80°7'0"W
80°6'0"W
80°5'0"W
80°4'0"W
80°3'0"W

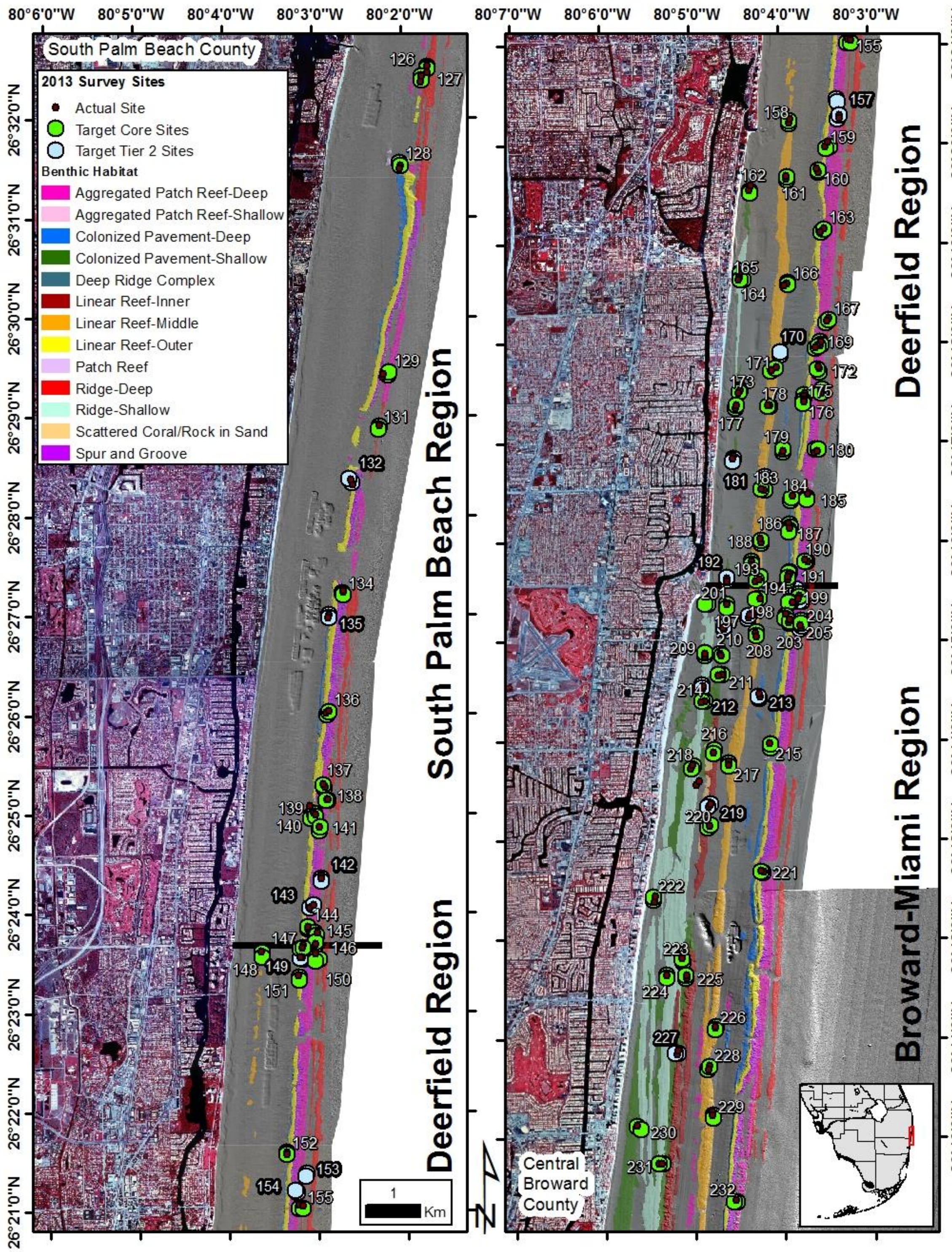


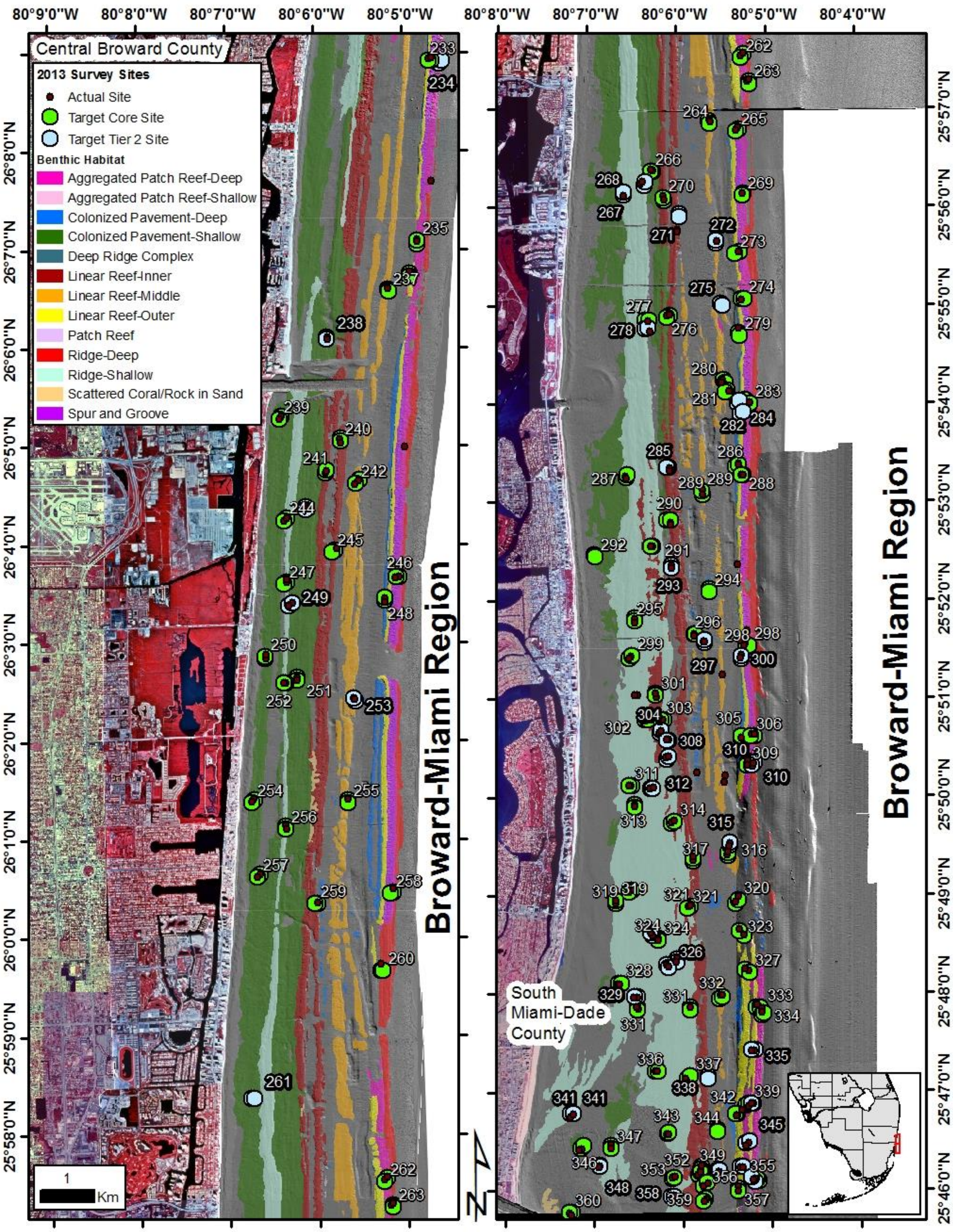
Central Broward County
2012 Survey Sites
Actual Location
Target
Benthic Habitats
Aggregated Patch Reef-Deep
Aggregated Patch Reef-Shallow
Colonized Pavement-Deep
Colonized Pavement-Shallow
Deep Ridge Complex
Linear Reef-Inner
Linear Reef-Middle
Linear Reef-Outer
Patch Reef
Ridge-Deep
Ridge-Shallow
Scattered Coral/Rock in Sand
Spur and Groove
Broward-Miami Region
South Miami-Dade County
Broward-Miami Region
1
Km
N
80°9'0"W
80°8'0"W
80°7'0"W
80°6'0"W
80°5'0"W
80°8'0"W
80°7'0"W
80°6'0"W
80°5'0"W
80°4'0"W
26°8'0"N
26°7'0"N
26°6'0"N
26°5'0"N
26°4'0"N
26°3'0"N
26°2'0"N
26°1'0"N
26°0'0"N
25°59'0"N
25°58'0"N
25°57'0"N
25°56'0"N
25°55'0"N
25°54'0"N
25°53'0"N
25°52'0"N
25°51'0"N
25°50'0"N
25°49'0"N
25°48'0"N
25°47'0"N
25°46'0"N

Appendix 4. 2013 site maps. Green indicates Core Target Site, Blue indicates Tier 2 Target Site, and small points indicate actual survey locations. Target sites without corresponding "Actual" sites were not surveyed.

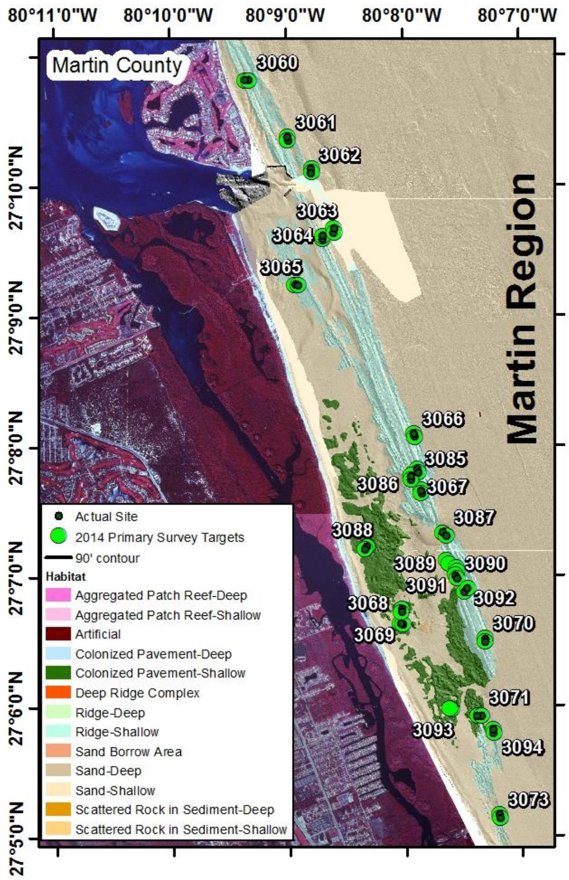


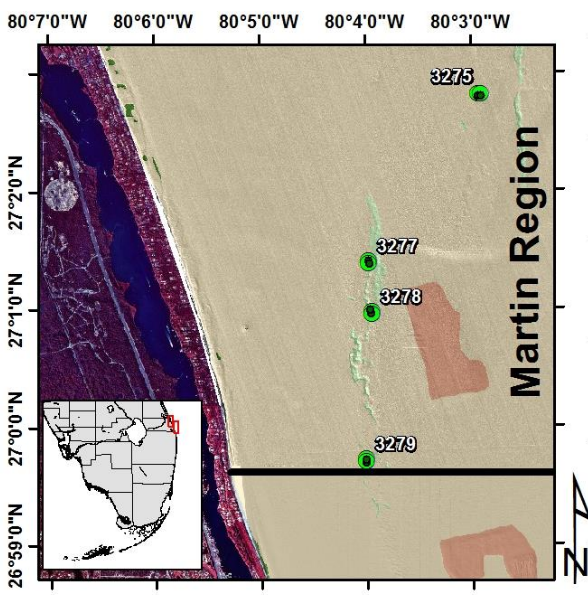

North Palm Beach County
South Palm Beach County
North Palm Beach Region
South Palm Beach Region
80°4'0"W
80°3'0"W
80°2'0"W
80°1'0"W
80°0'0"W
26°57'0"N
26°56'0"N
26°55'0"N
26°54'0"N
26°53'0"N
26°52'0"N
26°51'0"N
26°50'0"N
26°49'0"N
26°48'0"N
26°47'0"N
26°46'0"N
26°44'0"N
26°43'0"N
26°42'0"N
26°41'0"N
26°40'0"N
26°39'0"N
26°38'0"N
26°37'0"N
26°36'0"N
26°35'0"N
26°34'0"N
26°33'0"N
1
Km
2013 Survey Sites
Actual Site
Target Core Sites
Target Tier 2 Sites
90' contour
Benthic Habitat
Aggregated Patch Reef-Deep
Aggregated Patch Reef-Shallow
Colonized Pavement-Deep
Colonized Pavement-Shallow
Deep Ridge Complex
Linear Reef-Inner
Linear Reef-Middle
Linear Reef-Outer
Patch Reef
Ridge-Deep
Ridge-Shallow
Scattered Coral/Rock in Sand
Spur and Groove
N

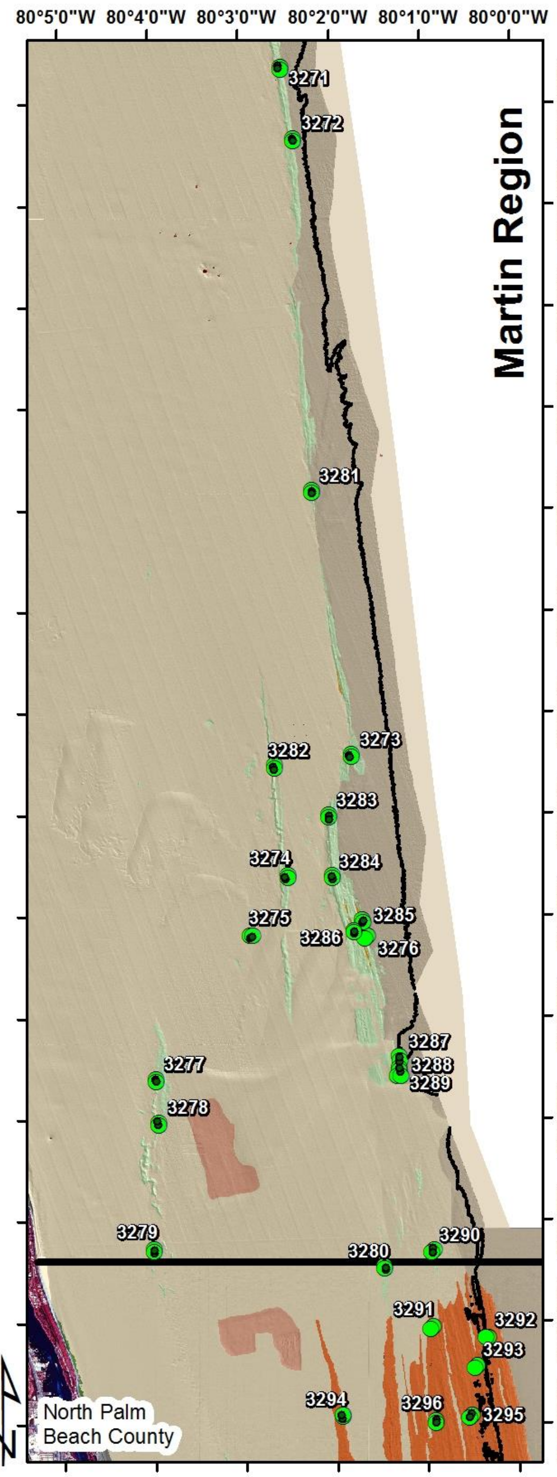

South Palm Beach County
2013 Survey Sites
Actual Site
Target Core Sites
Target Tier 2 Sites
Benthic Habitat
Aggregated Patch Reef-Deep
Aggregated Patch Reef-Shallow
Colonized Pavement-Deep
Colonized Pavement-Shallow
Deep Ridge Complex
Linear Reef-Inner
Linear Reef-Middle
Linear Reef-Outer
Patch Reef
Ridge-Deep
Ridge-Shallow
Scattered Coral/Rock in Sand
Spur and Groove
South Palm Beach Region
Deerfield Region
Broward-Miami Region
Central Broward County
1 Km
N
80°6'0"W 80°5'0"W 80°4'0"W 80°3'0"W 80°2'0"W
80°7'0"W 80°6'0"W 80°5'0"W 80°4'0"W 80°3'0"W
26°32'0"N 26°31'0"N 26°30'0"N 26°29'0"N 26°28'0"N 26°27'0"N 26°26'0"N 26°25'0"N 26°24'0"N 26°23'0"N 26°22'0"N 26°21'0"N
26°21'0"N 26°20'0"N 26°19'0"N 26°18'0"N 26°17'0"N 26°16'0"N 26°15'0"N 26°14'0"N 26°13'0"N 26°12'0"N 26°11'0"N 26°10'0"N

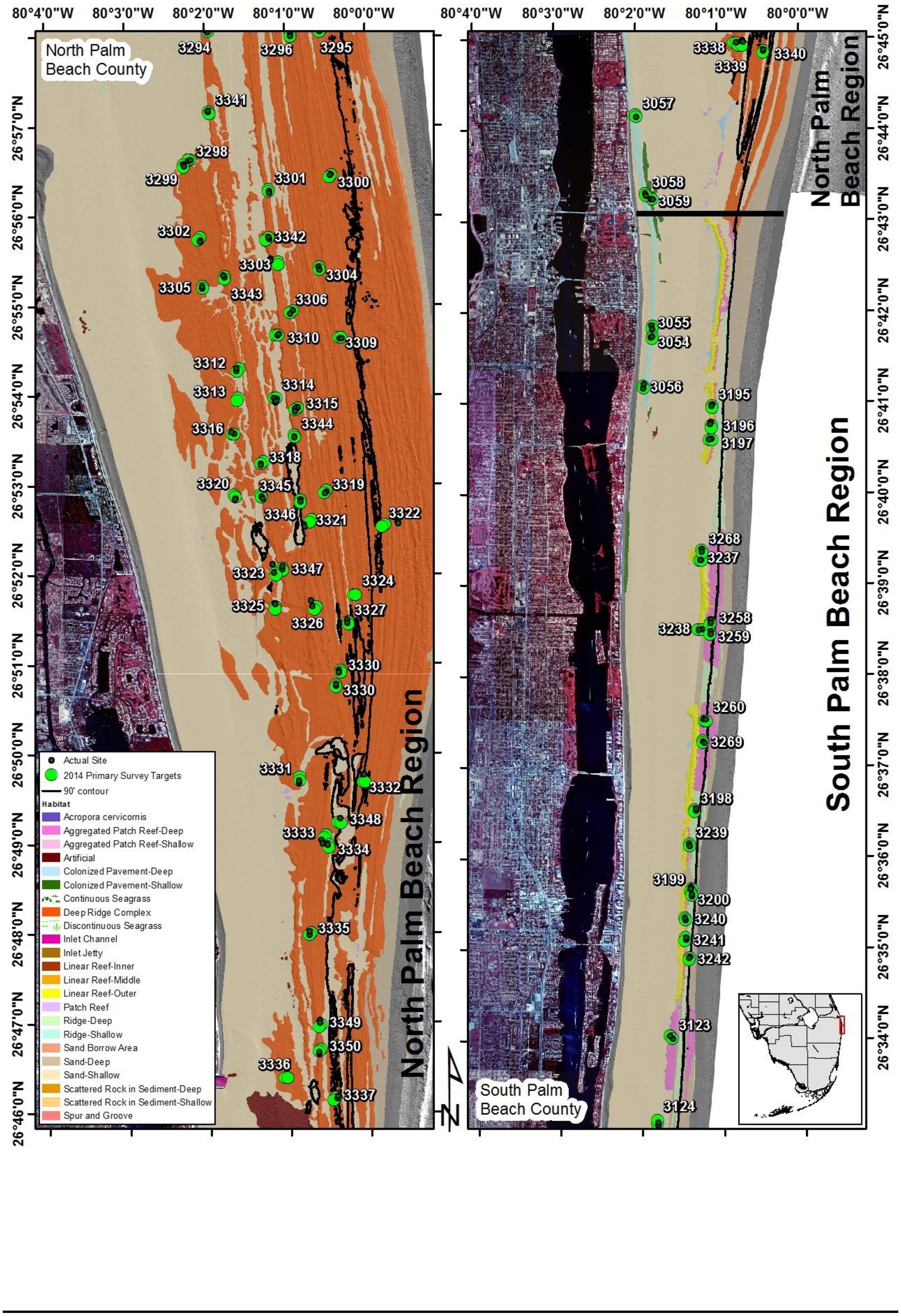

Central Broward County
2013 Survey Sites
Actual Site
Target Core Site
Target Tier 2 Site
Benthic Habitat
Aggregated Patch Reef-Deep
Aggregated Patch Reef-Shallow
Colonized Pavement-Deep
Colonized Pavement-Shallow
Deep Ridge Complex
Linear Reef-Inner
Linear Reef-Middle
Linear Reef-Outer
Patch Reef
Ridge-Deep
Ridge-Shallow
Scattered Coral/Rock in Sand
Spur and Groove
Broward-Miami Region
South Miami-Dade County
Broward-Miami Region
1 Km

Appendix 5. 2014 site maps. Green indicates Target Site and small points indicate actual survey locations. Target sites without corresponding "actual" sites were not surveyed.









North Palm Beach County
North Palm Beach Region
South Palm Beach County
South Palm Beach Region
Actual Site
2014 Primary Survey Targets
90' contour
Habitat
Acropora cervicornis
Aggregated Patch Reef-Deep
Aggregated Patch Reef-Shallow
Artificial
Colonized Pavement-Deep
Colonized Pavement-Shallow
Continuous Seagrass
Deep Ridge Complex
Discontinuous Seagrass
Inlet Channel
Inlet Jetty
Linear Reef-Inner
Linear Reef-Middle
Linear Reef-Outer
Patch Reef
Ridge-Deep
Ridge-Shallow
Sand Borrow Area
Sand-Deep
Sand-Shallow
Scattered Rock in Sediment-Deep
Scattered Rock in Sediment-Shallow
Spur and Groove
80°4'0"W
80°3'0"W
80°2'0"W
80°1'0"W
80°0'0"W
26°57'0"N
26°56'0"N
26°55'0"N
26°54'0"N
26°53'0"N
26°52'0"N
26°51'0"N
26°50'0"N
26°49'0"N
26°48'0"N
26°47'0"N
26°46'0"N
26°45'0"N
26°44'0"N
26°43'0"N
26°42'0"N
26°41'0"N
26°40'0"N
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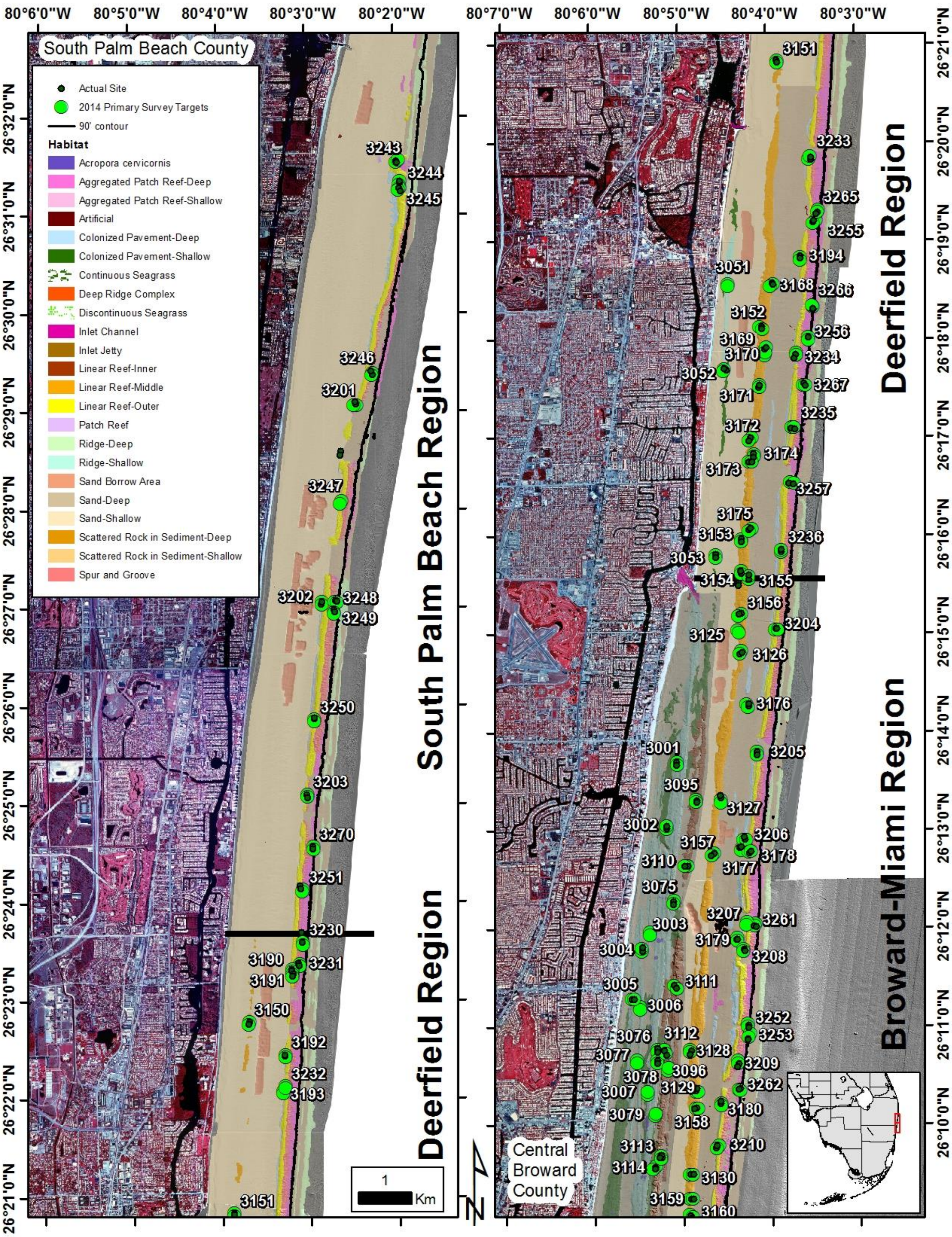
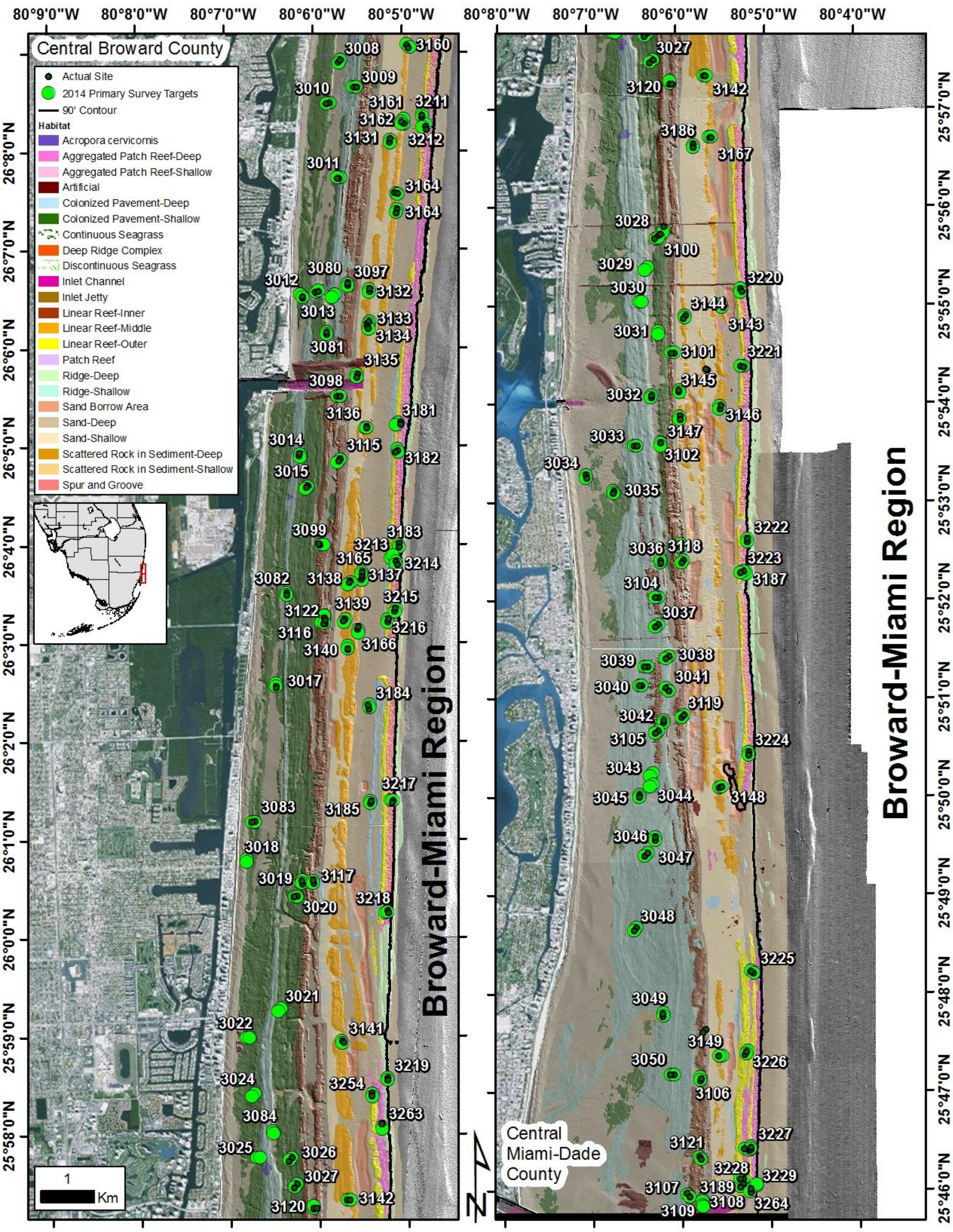
26°36'0"N
26°35'0"N
26°34'0"N
N


South Palm Beach County
Actual Site
2014 Primary Survey Targets
90' contour
Habitat
Acropora cervicornis
Aggregated Patch Reef-Deep
Aggregated Patch Reef-Shallow
Artificial
Colonized Pavement-Deep
Colonized Pavement-Shallow
Continuous Seagrass
Deep Ridge Complex
Discontinuous Seagrass
Inlet Channel
Inlet Jetty
Linear Reef-Inner
Linear Reef-Middle
Linear Reef-Outer
Patch Reef
Ridge-Deep
Ridge-Shallow
Sand Borrow Area
Sand-Deep
Sand-Shallow
Scattered Rock in Sediment-Deep
Scattered Rock in Sediment-Shallow
Spur and Groove
South Palm Beach Region
Deerfield Region
Broward-Miami Region
Central Broward County
1 Km
N



Central Broward County
Actual Site
2014 Primary Survey Targets
90' Contour
Habitat
Acropora cervicornis
Aggregated Patch Reef-Deep
Aggregated Patch Reef-Shallow
Artificial
Colonized Pavement-Deep
Colonized Pavement-Shallow
Continuous Seagrass
Deep Ridge Complex
Discontinuous Seagrass
Inlet Channel
Inlet Jetty
Linear Reef-Inner
Linear Reef-Middle
Linear Reef-Outer
Patch Reef
Ridge-Deep
Ridge-Shallow
Sand Borrow Area
Sand-Deep
Sand-Shallow
Scattered Rock in Sediment-Deep
Scattered Rock in Sediment-Shallow
Spur and Groove
Broward-Miami Region
Central Miami-Dade County
Broward-Miami Region
1 Km

Appendix 6. Average percent occurrence ($\bar{P}$) per SSU, average density ($\bar{D}$) per SSU, survey precision (CV of $\bar{D}$, percent) and range of CV for the three year period 2012-2014 for the SEFCRI region (three annual surveys) and 15 year period 1999-2013 for the Florida Keys (10 annual surveys) and the Dry Tortugas (5 annual surveys). Species analyzed had mean percent occurrence greater than 10% in one or both regions (73 species total). Species with values highlighted in pink were not observed with greater than 10% occurrence in the SEFCRI region. Species with values highlighted in gray were not observed with greater than 10% occurrence in the Florida Keys and Dry Tortugas.

Species	Family	SEFCRI REGION			FLORIDA KEYS			DRY TORTUGAS		
EXPLOITED		$\bar{P}$	$\bar{D}$	CV($\bar{D}$),Range	$\bar{P}$	$\bar{D}$	CV($\bar{D}$),Range	$\bar{P}$	$\bar{D}$	CV($\bar{D}$),Range
***Grey Triggerfish** (*Balistes capriscus*)	Balistidae	40.9	1.16	20.8 (12.6, 31.4)	-	-	-	-	-	-
Bar Jack (*Caranx ruber*)	Carangidae	27.4	1.08	27.3 (18.1, 36.3)	35.5	2.97	24.2 (18.5, 40.0)	23.4	3.63	26.8 (20.4, 36.8)
Porkfish (*Anisotremus virginicus*)	Haemulidae	40.3	1.43	18.3 (16.8, 20.8)	41.9	1.23	18.3 (11.9, 52.9)	17.8	0.55	34.0 (17.1, 60.4)
Tomtate (*Haemulon aurolineatum*)	Haemulidae	12.8	6.00	24.1 (22.5, 26.0)	18.5	13.66	34.9 (23.6, 73.9)	31.9	25.96	22.5 (13.8, 29.8)
French Grunt (*Haemulon flavolineatum*)	Haemulidae	15.2	3.27	33.2 (23.0, 41.9)	38.0	3.63	19.7 (15.4, 30.0)	14.9	0.82	30.7 (18.4, 39.7)
***White Grunt** (*Haemulon plumierii*)	Haemulidae	39.8	1.62	7.8 (7.8, 12.1)	73.5	8.96	14.1 (7.6, 22.8)	79.6	6.58	17.2 (13.8, 21.8)
***Bluestriped Grunt** (*Haemulon sciurus*)	Haemulidae	14.8	1.25	35.5 (18.7, 51.5)	-	-	-	-	-	-
***Hogfish** (*Lachnolaimus maximus*)	Labridae	22.6	0.31	12.6 (10.0, 14.6)	62.5	1.15	10.1 (6.6, 13.6)	48.1	0.55	10.7 (8.6, 13.6)
***Mutton Snapper** (*Lutjanus analis*)	Lutjanidae	26.2	0.24	17.1 (10.4, 26.0)	17.8	0.18	17.5 (10.0, 29.2)	22.8	0.19	14.8 (9.0, 21.8)
***Grey Snapper** (*Lutjanus griseus*)	Lutjanidae	9.4	0.36	25.2 (23.0, 27.1)	27.5	2.27	22.9 (16.8, 34.0)	15.2	2.73	49.7 (18.3, 70.0)
***Yellowtail Snapper** (*Ocyurus chrysurus*)	Lutjanidae	26.3	0.97	27.8 (17.8, 35.0)	58.5	4.12	12.3 (7.4, 18.0)	75.7	7.56	15.1 (7.9, 26.9)
Graysby (*Cephalopholis cruentata*)	Serranidae	17.8	0.16	15.5 (9.0, 26.3)	32.1	0.30	10.6 (7.1, 14.7)	31.6	0.27	10.7 (7.0, 13.8)
***Red Grouper** (*Epinephelus morio*)	Serranidae	8.4	0.06	21.8 (18.0, 28.4)	20.4	0.16	14.2 (10.7, 20.0)	62.2	0.62	6.7 (5.9, 7.8)
Black Grouper (*Mycteroperca bonaci*)	Serranidae	1.2	0.01	48.6 (35.9, 64.4)	16.2	0.14	16.2 (11.2, 27.0)	22.2	0.22	14.1 (9.6, 18.4)
Gag (*Mycteroperca microlepis*)	Serranidae	0.3	0.00	46.6 (38.9, 58.3)	-	-	-	-	-	-
Scamp (*Mycteroperca phenax*)	Serranidae	0.8	0.00	40.2 (29.0, 54.5)	-	-	-	-	-	-
Great Barracuda (*Sphyraena barracuda*)	Sphyraenidae	1.4	0.02	46.8 (38.4, 52.8)	10.7	0.11	23.3 (15.5, 33.7)	17.1	0.21	30.1 (14.9, 52.0)
NON-TARGET & AQUARIUM										
Ocean Surgeon (*Acanthurus bahianus*)	Acanthuridae	76.0	4.47	7.4 (5.5, 10.4)	79.7	3.53	7.3 (5.7, 10.9)	60.5	1.21	10.5 (8.0, 14.4)
Doctorfish (*Acanthurus chirurgus*)	Acanthuridae	65.0	3.02	9.1 (6.6, 11.6)	56.2	2.18	12.0 (8.5, 17.0)	30.0	0.50	16.8 (14.5, 19.0)
Blue Tang (*Acanthurus coeruleus*)	Acanthuridae	44.8	1.33	13.1 (9.5, 17.1)	77.5	2.92	9.7 (6.4, 15.8)	77.7	2.25	8.1 (7.0, 10.1)
Seaweed Blenny (*Parablennius marmoreus*)	Blenniidae	12.1	0.14	25.6 (18.7, 31.7)	-	-	-	-	-	-
Foureye Butterflyfish (*Chaetodon capistratus*)	Chaetodontidae	10.4	0.13	20.1 (12.6, 24.0)	41.5	0.60	10.5 (7.0, 24.5)	39.8	0.59	9.1 (6.0, 10.9)
Spotfin Butterflyfish (*Chaetodon ocellatus*)	Chaetodontidae	24.4	0.31	12.2 (8.5, 16.0)	42.8	0.53	8.5 (6.2, 12.1)	53.7	0.69	6.9 (5.3, 7.6)

Appendix 6. (continued)

Species	Family	SEFCRI REGION $\bar{P}$	SEFCRI REGION $\bar{D}$	SEFCRI REGION CV($\bar{D}$),Range	FLORIDA KEYS $\bar{P}$	FLORIDA KEYS $\bar{D}$	FLORIDA KEYS CV($\bar{D}$),Range	DRY TORTUGAS $\bar{P}$	DRY TORTUGAS $\bar{D}$	DRY TORTUGAS CV($\bar{D}$),Range
Reef Butterflyfish (*Chaetodon sedentarius*)	Chaetodontidae	41.7	0.75	7.1 (5.8, 8.3)	32.5	0.45	10.4 (7.2, 14.7)	27.0	0.29	13.3 (10.6, 17.1)
Bridled Goby (*Coryphopterus glaucofraenum*)	Gobiidae	21.6	0.42	17.2 (16.4, 18.5)	-	-	-	-	-	-
Masked Goby (*Coryphopterus personatus*)	Gobiidae	18.8	9.36	18.5 (14.6, 21.1)	-	-	-	-	-	-
Neon Goby (*Elacatinus oceanops*)	Gobiidae	11.0	0.15	23.1 (16.1, 30.5)	-	-	-	-	-	-
Grunt species (*Haemulon spp.*)	Haemulidae	23.7	7.49	27.7 (25.0, 29.2)	-	-	-	-	-	-
Squirrelfish (*Holocentrus adscensionis*)	Holocentridae	14.8	0.14	18.3 (14.0, 24.0)	10.2	0.14	24.6 (19.6, 36.5)	13.4	0.17	26.7 (16.8, 41.0)
Spanish Hogfish (*Bodianus rufus*)	Labridae	26.9	0.30	14.5 (9.9, 17.4)	23.8	0.25	13.7 (9.6, 19.1)	21.5	0.19	14.6 (8.8, 18.5)
Slippery Dick (*Halichoeres bivittatus*)	Labridae	66.9	4.38	9.6 (7.6, 11.7)	70.0	4.85	8.8 (7.6, 10.7)	77.2	7.18	7.8 (6.0, 9.6)
Yellowcheek Wrasse (*Halichoeres cyanocephalus*)	Labridae	10.6	0.08	28.2 (20.9, 40.9)	-	-	-	-	-	-
Yellowhead Wrasse (*Halichoeres garnoti*)	Labridae	57.4	4.28	8.8 (6.8, 9.9)	67.7	3.30	8.3 (5.1, 18.5)	81.6	3.95	7.4 (4.2, 11.8)
Clown Wrasse (*Halichoeres maculipinna*)	Labridae	42.1	1.65	14.0 (10.8, 17.5)	56.4	2.31	8.7 (6.7, 11.4)	42.6	0.89	13.0 (9.6, 20.3)
Puddingwife (*Halichoeres radiatus*)	Labridae	6.9	0.05	34.6 (28.0, 38.2)	27.2	0.25	12.1 (7.9, 18.7)	11.9	0.09	21.3 (15.3, 36.2)
Bluehead (*Thalasoma bifasciatum*)	Labridae	75.0	14.97	8.4 (7.0, 10.5)	92.1	17.69	6.6 (4.0, 9.4)	94.8	15.58	8.1 (4.8, 15.8)
Green Razorfish (*Xyrichtys splendens*)	Labridae	22.6	0.97	37.1 (20.5, 64.7)	-	-	-	-	-	-
Scrawled Filefish (*Aluterus scriptus*)	Monacanthidae	11.9	0.10	16.8 (12.9, 20.5)	-	-	-	-	-	-
Orangespotted Filefish (*Cantherhines pullus*)	Monacanthidae	11.6	0.08	17.5 (13.6, 20.3)	-	-	-	-	-	-
Spotted Goatfish (*Pseudupeneus maculatus*)	Mullidae	45.0	1.00	13.6 (8.4, 19.7)	35.9	0.67	19.1 (8.4, 57.0)	62.0	1.10	9.7 (8.0, 12.0)
Yellowhead Jawfish (*Opistognathus aurifrons*)	Opistignathidae	13.4	0.24	24.7 (17.1, 33.7)	10.7	0.25	26.7 (16.8, 46.1)	49.8	2.59	14.2 (10.1, 17.5)
Scrawled Cowfish (*Acanthostracion quadricornis*)	Ostraciidae	10.5	0.07	22.1 (15.1, 31.7)	-	-	-	-	-	-
Smooth Trunkfish (*Rhinesomus triqueter*)	Ostraciidae	10.7	0.07	16.6 (14.3, 18.9)	-	-	-	-	-	-
Blue Angelfish (*Holacanthus bermudensis*)	Pomacanthidae	17.1	0.16	19.3 (11.6, 29.2)	16.6	0.14	16.5 (12.2, 23.3)	57.1	0.83	7.2 (5.5, 8.6)
Queen Angelfish (*Holacanthus ciliaris*)	Pomacanthidae	17.2	0.15	16.9 (12.2, 24.8)	27.2	0.23	12.7 (7.9, 19.7)	23.4	0.20	12.9 (9.0, 15.3)
Rock Beauty (*Holacanthus tricolor*)	Pomacanthidae	30.6	0.43	10.3 (6.3, 16.1)	-	-	-	-	-	-
Gray Angelfish (*Pomacanthus arcuatus*)	Pomacanthidae	40.6	0.48	10.6 (7.4, 14.2)	58.1	0.82	10.1 (5.4, 23.1)	46.0	0.58	12.7 (7.6, 27.3)
French Angelfish (*Pomacanthus paru*)	Pomacanthidae	27.0	0.26	15.8 (10.4, 23.8)	21.1	0.19	14.8 (11.9, 20.1)	14.3	0.12	17.3 (13.5, 20.7)
Sergent Major (*Abudefduf saxatilis*)	Pomacentridae	12.3	1.46	28.6 (19.1, 35.8)	-	-	-	-	-	-
Blue Chromis (*Chromis cyanea*)	Pomacentridae	16.3	1.51	18.9 (13.1, 29.5)	21.9	1.37	17.2 (12.4, 27.2)	23.3	0.95	24.7 (11.3, 43.9)
Yellowtail Reeffish (*Chromis enchrysura*)	Pomacentridae	17.6	0.58	29.6 (20.3, 44.8)	-	-	-	-	-	-
Sunshinefish (*Chromis insolata*)	Pomacentridae	16.8	1.16	23.1 (13.1, 32.7)	-	-	-	-	-	-
Beaugregory (*Stegastes leucostictus*)	Pomacentridae	20.0	0.33	19.0 (17.3, 21.8)	24.2	0.27	14.8 (8.7, 23.9)	34.6	0.58	12.0 (10.1, 13.5)

Appendix 6. (continued)

Species	Family	SEFCRI REGION $\bar{P}$	SEFCRI REGION $\bar{D}$	SEFCRI REGION CV($\bar{D}$),Range	FLORIDA KEYS $\bar{P}$	FLORIDA KEYS $\bar{D}$	FLORIDA KEYS CV($\bar{D}$),Range	DRY TORTUGAS $\bar{P}$	DRY TORTUGAS $\bar{D}$	DRY TORTUGAS CV($\bar{D}$),Range
Bicolor Damselfish (*Stegastes partitus*)	Pomacentridae	73.5	18.39	8.1 (5.6, 11.2)	81.0	19.55	8.4 (5.7, 12.2)	73.9	7.71	8.6 (6.7, 11.2)
Threespot Damselfish (*Stegastes planifrons*)	Pomacentridae	2.7	0.03	33.6 (29.7, 39.1)	28.6	0.61	14.5 (9.9, 20.2)	36.0	1.08	12.1 (8.7, 20.5)
Cocoa Damselfish (*Stegastes variabilis*)	Pomacentridae	39.1	0.75	19.4 (8.9, 24.8)	55.1	0.89	9.5 (5.8, 14.0)	91.8	5.07	5.2 (4.3, 6.5)
Bluelip Parrotfish (*Cryptotomus roseus*)	Scaridae	24.4	0.82	17.8 (12.0, 22.4)	-	-	-	-	-	-
Striped Parrotfish (*Scarus iseri*)	Scaridae	32.0	1.71	16.7 (9.4, 25.9)	80.2	7.55	7.1 (5.2, 9.9)	91.6	11.22	13.4 (4.5, 41.5)
Princess Parrotfish (*Scarus taeniopterus*)	Scaridae	22.2	0.63	17.1 (11.4, 27.7)	16.7	0.34	21.5 (12.5, 27.4)	12.0	0.28	21.7 (13.0, 30.8)
Greenblotch Parrotfish (*Sparisoma atomarium*)	Scaridae	42.8	1.58	13.9 (11.0, 16.8)	40.9	1.01	12.3 (7.7, 18.4)	49.7	1.10	12.9 (9.0, 22.5)
Redband Parrotfish (*Sparisoma aurofrenatum*)	Scaridae	59.0	3.23	7.9 (7.5, 8.5)	88.5	3.97	6.0 (3.9, 8.2)	83.9	2.94	13.0 (4.8, 23.2)
Redtail Parrotfish (*Sparisoma chrysopterum*)	Scaridae	8.6	0.12	23.7 (17.3, 31.7)	27.3	0.57	18.4 (12.2, 25.6)	14.5	0.18	25.7 (18.8, 32.5)
Yellowtail Parrotfish (*Sparisoma rubripinne*)	Scaridae	10.4	0.13	23.6 (21.4, 25.3)	19.7	0.34	20.9 (12.2, 30.1)	11.0	0.13	23.0 (15.9, 30.3)
Stoplight Parrotfish (*Sparisoma viride*)	Scaridae	29.4	0.48	12.0 (9.0, 14.6)	64.2	1.41	8.7 (6.4, 11.9)	60.5	1.20	9.9 (5.8, 12.5)
High-hat (*Pareques acuminatus*)	Sciaenidae	11.2	0.18	27.9 (25.4, 29.7)	-	-	-	-	-	-
Red Lionfish (*Pterois volitans*)	Scorpanidae	11.3	0.11	22.6 (17.5, 30.9)	-	-	-	-	-	-
Butter Hamlet (*Hypoplectrus unicolor*)	Serranidae	15.0	0.18	14.6 (14.6, 30.3)	32.9	0.33	11.1 (7.2, 19.4)	48.4	0.62	9.4 (5.9, 17.3)
Lantern Bass (*Serranus baldwini*)	Serranidae	18.9	0.17	19.8 (13.8, 28.9)	-	-	-	-	-	-
Tobaccofish (*Serranus tabacarius*)	Serranidae	10.3	0.11	18.3 (16.0, 21.0)	9.9	0.12	23.6 (16.9, 32.5)	14.6	0.18	23.7 (19.2, 36.0)
Harlequin Bass (*Serranus tigrinus*)	Serranidae	28.7	0.35	12.6 (7.3, 18.7)	35.4	0.35	9.6 (7.6, 12.5)	34.0	0.34	12.2 (8.7, 17.9)
Saucereye Porgy (*Calamus calamus*)	Sparidae	15.9	0.18	21.4 (16.1, 31.3)	35.3	0.45	13.1 (9.4, 25.1)	75.5	1.43	8.8 (7.1, 11.5)
Sharpnose Puffer (*Canthigaster rostrata*)	Tetraodontidae	79.8	2.34	6.8 (5.8, 8.7)	44.4	0.48	8.7 (5.7, 12.4)	30.9	0.28	13.3 (7.1, 19.0)
Bandtail Puffer (*Sphoeroides spengleri*)	Tetraodontidae	13.1	0.10	20.5 (13.9, 28.1)	-	-	-	-	-	-

Appendix 7. Percent Occurrence ($\bar{P}$), Mean Density ($\bar{D}$), and Coefficient of Variation (CV) for all species observed for all three years, in alphabetical order by family.

Common Name	Species	Family	2012			2013			2014		
			$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)
Ocean Surgeon	*Acanthurus bahianus*	Acanthuridae	0.85	4.74	5.49	0.71	4.48	6.29	0.69	3.69	10.41
Doctorfish	*Acanthurus chirurgus*	Acanthuridae	0.58	2.51	11.56	0.65	2.94	6.64	0.65	3.11	9.11
Blue Tang	*Acanthurus coeruleus*	Acanthuridae	0.47	1.86	17.07	0.47	1.40	9.48	0.32	0.84	12.90
Surgeonfish species	*Acanthurus* spp.	Acanthuridae	0.10	0.30	30.72	0.04	0.07	46.55	0.0005	0.001	70.49
Cardinalfish species	*Astrapogon* spp.	Apogonidae	0.005	0.003	92.02	0.003	0.003	80.19	0.01	0.01	93.24
Barred Cardinalfish	*Apogon binotatus*	Apogonidae	0.004	0.002	49.20	0.004	0.003	50.17	0.01	0.004	58.56
Flamefish	*Apogon maculatus*	Apogonidae	0.008	0.004	46.23	0.01	0.02	61.82	0.01	0.01	64.89
Twospot Cardinalfish	*Apogon pseudomaculatus*	Apogonidae	0.004	0.008	88.90	0.02	0.05	51.97	0.01	0.01	57.25
Sawcheek Cardinalfish	*Apogon quadrisquamatus*	Apogonidae	-	-	-	0.001	0.001	100.57	-	-	-
Belted Cardinalfish	*Apogon townsendi*	Apogonidae	-	-	-	0.006	0.004	48.61	0.003	0.002	43.28
Trumpetfish	*Aulostomus maculatus*	Aulostomidae	0.12	0.13	25.23	0.06	0.05	26.85	0.06	0.06	24.83
Gray Triggerfish	*Balistes capriscus*	Balistidae	0.31	0.63	31.38	0.39	0.93	12.58	0.51	2.09	18.31
Queen Triggerfish	*Balistes vetula*	Balistidae	0.03	0.01	86.51	0.03	0.02	33.54	0.01	0.01	40.88
Ocean Triggerfish	*Canthidermis sufflamen*	Balistidae	0.01	0.007	42.1	0.02	0.02	34.08	0.02	0.02	38.70
Black Durgon	*Melichthys niger*	Balistidae	-	-	-	-	-	-	0.001	0.0003	101.06
Oyster Toadfish	*Opsanus tau*	Batrachoididae	-	-	-	0.004	0.003	99.53	-	-	-
Blenny species	Blenny spp.	Blenniidae	0.01	0.006	40.29	0.02	0.01	41.85	0.01	0.02	83.81
Barred Blenny	*Hypleurochilus bermudensis*	Blenniidae	0.003	0.002	80.01	0.003	0.002	100.05	0.001	0.001	98.55
Redlip Blenny	*Ophioblennius macclurei*	Blenniidae	-	-	-	0.007	0.005	70.08	0.0003	0.0001	92.29
Seaweed Blenny	*Parablennius marmoreus*	Blenniidae	0.11	0.12	26.31	0.11	0.11	18.67	0.14	0.21	31.72
Molly Miller	*Scartella cristata*	Blenniidae	0.01	0.02	54.40	0.002	0.004	100.26	0.0002	0.0001	100.57
Peacock Flounder	*Bothus lunatus*	Bothidae	-	-	-	0.0003	0.0002	102.72	0.004	0.002	100.06

Appendix 7.(continued)

Common Name	Species	Family	2012			2013			2014		
			$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)
Eyed Flounder	*Bothus ocellatus*	Bothidae	-	-	-	0.001	0.003	97.68	-	-	-
Black Brotula	*Stygnobrotula latebricola*	Bythitidae	0.001	0.001	98.00	-	-	-	-	-	-
Lancer Dragonet	*Callionymus bairdi*	Callionymidae	-	-	-	-	-	-	0.01	0.01	100.27
Yellow Jack	*Carangoides bartholomaei*	Carangidae	0.08	0.12	51.21	0.06	0.09	26.87	0.05	0.27	80.20
Bar Jack	*Caranx ruber*	Carangidae	0.34	2.09	27.39	0.24	0.54	18.13	0.26	0.95	36.31
Jack species	*Caranx* spp.	Carangidae	0.01	0.28	51.68	0.003	0.001	68.18	0.01	0.01	73.65
Blue Runner	*Caranx crysos*	Carangidae	0.07	0.70	35.38	0.10	0.62	25.60	0.19	0.82	21.84
Crevalle Jack	*Caranx hippos*	Carangidae	0.004	0.006	84.90	0.005	0.009	49.56	0.0001	0.02	102.44
Horse-eye Jack	*Caranx latus*	Carangidae	-	-	-	0.001	0.007	100.57	0.0002	0.0003	100.57
Black Jack	*Caranx lugubris*	Carangidae	-	-	-	0.002	0.001	100.26	-	-	-
Atlantic Bumper	*Chloroscombrus chrysurus*	Carangidae	0.006	0.24	88.48	0.006	0.94	93.58	0.01	1.92	98.86
Scad species	*Decapterus* spp.	Carangidae	-	-	-	0.001	0.05	100.57	0.01	0.03	67.89
Mackerel Scad	*Decapterus macarellus*	Carangidae	0.01	1.04	56.03	0.008	0.91	67.05	0.001	0.08	88.07
Round Scad	*Decapterus punctatus*	Carangidae	0.005	0.47	61.78	0.02	2.19	47.50	0.01	0.30	53.77
Rainbow Runner	*Elagatis bipinnulata*	Carangidae	-	-	-	0.01	0.14	44.75	0.03	0.44	62.00
Leatherjack	*Oligoplites saurus*	Carangidae	0.001	0.002	101.80	-	-	-	0.0001	0.0001	102.44
Greater Amberjack	*Seriola dumerili*	Carangidae	0.003	0.005	88.57	0.005	0.02	56.92	0.01	0.01	63.18
Almaco Jack	*Seriola rivoliana*	Carangidae	0.09	0.22	41.97	0.01	0.03	59.59	0.04	0.12	45.87
Jack species	*Seriola* spp.	Carangidae	-	-	-	0.001	0.002	83.72	-	-	-
Banded Rudderfish	*Seriola zonata*	Carangidae	-	-	-	0.0005	0.0002	100.69	0.01	0.01	65.23
Permit	*Trachinotus falcatus*	Carangidae	0.003	0.001	100.77	-	-	-	0.001	0.0004	100.39
Pompano	*Trachinotus goodei*	Carangidae	-	-	-	-	-	-	0.0001	0.0001	102.44

Appendix 7. (continued)

Common Name	Species	Family	2012			2013			2014		
			$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)
Rough Scad	*Trachurus lathami*	Carangidae	-	-	-	0.001	0.004	102.25	-	-	-
Bull Shark	*Carcharhinus leucas*	Carcharhinidae	0.005	0.003	99.58	0.001	0.0005	97.68	0.005	0.002	59.04
Tiger Shark	*Galeocerdo cuvier*	Carcharhinidae	-	-	-	-	-	-	0.004	0.002	100.06
Lemon Shark	*Negaprion brevirostris*	Carcharhinidae	-	-	-	0.004	0.002	89.35	-	-	-
Roughhead Blenny	*Acanthemblemaria aspera*	Chaenopsidae	0.01	0.008	51.02	0.002	0.001	100.26	-	-	-
Secretary Blenny	*Acanthemblemaria maria*	Chaenopsidae	-	-	-	0.0005	0.0002	106.61	-	-	-
Sailfin Blenny	*Emblemaria pandionis*	Chaenopsidae	0.02	0.01	34.81	0.003	0.003	66.22	0.03	0.01	58.73
Wrasse Blenny	*Hemiemblemaria simulus*	Chaenopsidae	-	-	-	0.001	0.001	102.25	-	-	-
Foureye Butterflyfish	*Chaetodon capistratus*	Chaetodontidae	0.12	0.16	24.05	0.10	0.13	12.57	0.10	0.14	23.60
Spotfin Butterflyfish	*Chaetodon ocellatus*	Chaetodontidae	0.29	0.39	16.02	0.24	0.31	8.53	0.21	0.24	12.14
Reef Butterflyfish	*Chaetodon sedentarius*	Chaetodontidae	0.39	0.71	7.24	0.41	0.76	5.80	0.40	0.72	8.30
Banded Butterflyfish	*Chaetodon striatus*	Chaetodontidae	0.08	0.09	33.16	0.05	0.05	22.01	0.04	0.04	36.74
Longsnout Butterflyfish	*Prognathodes aculeatus*	Chaetodontidae	0.001	0.001	101.80	0.001	0.0004	102.25	-	-	-
Redspotted Hawkfish	*Amblycirrhitus pinos*	Cirrhitidae	-	-	-	0.004	0.002	56.69	0.0003	0.0002	101.68
Herring species	*Jenkinsia* spp.	Clupeidae	0.002	0.51	100.17	0.004	2.97	89.74	0.01	0.13	74.69
Spanish Sardine	*Sardinella aurita*	Clupeidae	-	-	-	0.001	0.003	105.47	0.0001	0.01	102.44
Brown Garden Eel	*Heteroconger longissimus*	Congridae	-	-	-	0.004	0.03	50.24	0.01	0.02	74.47
Flying Gurnard	*Dactylopterus volitans*	Dactylopteridae	0.001	0.0004	97.54	-	-	-	-	-	-
Southern Stingray	*Dasyatis americana*	Dasyatidae	0.01	0.006	58.73	0.003	0.002	64.29	0.01	0.01	62.43
Bridled Burrfish	*Chilomycterus antennatus*	Diodontidae	-	-	-	0.001	0.0004	97.56	-	-	-
Spotfin Burrfish	*Chilomycterus reticulatus*	Diodontidae	0.003	0.001	77.11	-	-	-	-	-	-
Striped Burrfish	*Chilomycterus schoepfii*	Diodontidae	0.003	0.001	77.11	0.002	0.004	87.11	-	-	-

Appendix 7. (continued)

Common Name	Species	Family	2012			2013			2014		
			$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)
Puffer species	*Diodon* spp.	Diodontidae	0.001	0.0004	100.69	0.004	0.005	96.22	-	-	-
Balloonfish	*Diodon holocanthus*	Diodontidae	0.07	0.04	17.00	0.08	0.05	14.87	0.06	0.04	27.71
Porcupine Puffer	*Diodon hystrix*	Diodontidae	0.02	0.008	51.87	0.02	0.01	31.44	0.0009	0.001	91.97
Sharksucker	*Echeneis naucrates*	Echeneidae	0.009	0.005	55.76	0.01	0.01	45.16	0.04	0.03	31.55
Whitefin Sharksucker	*Echeneis neucratoides*	Echeneidae	-	-	-	0.002	0.001	98.67	0.001	0.001	71.56
Shark species	*Elasmobranch* spp.	Elasmobranchiomorphi	-	-	-	0.001	0.001	77.71	-	-	-
Anchovy species	*Anchoa* spp.	Engraulidae	-	-	-	0.001	0.001	105.85	-	-	-
Atlantic Spadefish	*Chaetodipterus faber*	Ephippidae	0.03	0.22	56.78	0.04	0.18	54.31	0.03	0.15	30.28
Cornetfish	*Fistularia tabacaria*	Fistulariidae	0.04	0.02	55.76	0.02	0.02	29.09	0.01	0.01	40.62
Yellow Fin Mojarra	*Gerres cinereus*	Gerreidae	0.02	0.02	39.37	0.01	0.54	97.03	0.03	0.03	71.90
Mottled Mojarra	*Ulaema lefroyi*	Gerreidae	-	-	-	0.002	0.005	100.26	-	-	-
Nurse Shark	*Ginglymostoma cirratum*	Ginglymostomatidae	0.02	0.009	46.12	0.03	0.01	26.25	0.02	0.01	62.30
Colon Goby	*Coryphopterus dicrus*	Gobiidae	0.01	0.02	45.00	0.02	0.01	36.28	0.07	0.08	35.22
Bridled Goby	*Coryphopterus glaucofraenum*	Gobiidae	0.25	0.60	18.47	0.15	0.19	16.38	0.22	0.44	16.81
Masked Goby	*Coryphopterus personatus*	Gobiidae	0.21	8.68	19.81	0.15	4.34	14.62	0.21	13.85	21.12
Goby species	*Coryphopterus* spp.	Gobiidae	0.006	0.01	52.40	0.03	0.03	51.98	0.01	0.01	55.53
Pallid Goby	*Coryphopterus eidolon*	Gobiidae	0.001	0.0003	103.70	0.01	0.006	48.80	0.005	0.002	93.58
Peppermint Goby	*Coryphopterus lipernes*	Gobiidae	0.004	0.002	99.48	0.003	0.002	100.05	-	-	-
Dash Goby	*Ctenogobius saepepallens*	Gobiidae	0.003	0.002	59.77	-	-	-	0.0001	0.0001	102.44
Neon Goby	*Elacatinus oceanops*	Gobiidae	0.14	0.25	30.49	0.09	0.1	16.15	0.09	0.10	22.59
Yellowline Goby	*Elacatinus horsti*	Gobiidae	-	-	-	0.007	0.006	48.63	-	-	-
Yellowprow Goby	*Elacatinus xanthiprora*	Gobiidae	-	-	-	0.001	0.001	76.77	0.001	0.001	61.05

Appendix 7. (continued)

Common Name	Species	Family	2012			2013			2014		
			$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)
Goldspot Goby	*Gnatholepis thompsoni*	Gobiidae	0.09	0.10	30.73	0.11	0.10	17.18	0.14	0.24	43.24
Goby species	*Gobiidae* spp.	Gobiidae	0.008	0.006	46.88	0.003	0.001	99.17	0.01	0.01	66.99
Seminole Goby	*Microgobius carri*	Gobiidae	0.004	0.003	99.56	0.002	0.002	100.21	0.001	0.002	93.03
Rusty Goby	*Priolepis hipoliti*	Gobiidae	-	-	-	0.003	0.002	100.05	-	-	-
Black Margate	*Anisotremus surinamensis*	Haemulidae	0.10	0.13	39.21	0.07	0.11	28.88	0.04	0.05	20.62
Porkfish	*Anisotremus virginicus*	Haemulidae	0.46	1.48	20.83	0.40	1.51	16.8	0.35	0.99	17.25
Tomtate	*Haemulon aurolineatum*	Haemulidae	0.15	7.53	22.51	0.11	6.13	23.70	0.19	6.90	26.02
French Grunt	*Haemulon flavolineatum*	Haemulidae	0.22	3.04	22.95	0.14	4.59	34.61	0.11	2.21	41.90
White Grunt	*Haemulon plumierii*	Haemulidae	0.51	2.11	12.14	0.39	1.70	10.84	0.31	0.74	18.28
Bluestriped Grunt	*Haemulon sciurus*	Haemulidae	0.21	0.93	18.70	0.14	1.80	51.53	0.09	0.47	36.16
Grunt species	*Haemulon* spp.	Haemulidae	0.14	3.86	29.18	0.17	5.92	25.04	0.38	12.32	28.83
White Margate	*Haemulon album*	Haemulidae	0.003	0.006	79.93	0.04	0.04	28.11	0.002	0.001	58.23
Caesar Grunt	*Haemulon carbonarium*	Haemulidae	0.04	0.26	45.06	0.04	1.10	86.18	0.07	0.16	38.62
Smallmouth Grunt	*Haemulon chrysargyreum*	Haemulidae	0.04	0.42	65.06	0.01	0.28	60.48	0.003	0.04	58.04
Spanish Grunt	*Haemulon macrostomum*	Haemulidae	0.02	0.03	50.87	0.02	0.01	27.16	0.01	0.01	32.25
Cottonwick	*Haemulon melanurum*	Haemulidae	0.08	1.57	52.62	0.06	0.54	28.49	0.04	0.46	58.89
Sailor's Choice	*Haemulon parra*	Haemulidae	0.08	0.16	28.92	0.05	1.02	86.24	0.03	0.06	48.00
Striped Grunt	*Haemulon striatum*	Haemulidae	0.02	0.40	56.88	0.02	0.39	32.34	0.03	0.23	41.67
Boga	*Haemulon vittatum*	Haemulidae	-	-	-	0.001	0.16	96.71	-	-	-
Pigfish	*Orthopristis chrysoptera*	Haemulidae	0.003	0.003	89.93	-	-	-	0.0002	0.002	100.57
Ballyhoo	*Hemiramphus brasiliensis*	Hemiramphidae	-	-	-	0.01	0.71	75.30	0.001	0.03	78.17
Squirrelfish	*Holocentrus adscensionis*	Holocentridae	0.15	0.15	23.96	0.14	0.15	13.96	0.13	0.10	16.84

Appendix 7. (continued)

Common Name	Species	Family	2012			2013			2014		
			$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)
Squirrelfish species	*Holocentrus* spp.	Holocentridae	-	-	-	0.003	0.002	49.83	0.001	0.0004	100.39
Longspine Squirrelfish	*Holocentrus rufus*	Holocentridae	0.04	0.03	43.35	0.04	0.04	30.95	0.05	0.04	38.49
Blackbar Soldierfish	*Myripristis jacobus*	Holocentridae	0.05	0.21	65.72	0.02	0.04	45.60	0.01	0.04	33.43
Reef Squirrelfish	*Sargocentron coruscum*	Holocentridae	0.002	0.001	100.72	0.001	0.0004	102.25	0.01	0.01	52.59
Dusky Squirrelfish	*Sargocentron vexillarium*	Holocentridae	-	-	-	0.002	0.002	100.26	0.001	0.001	98.55
Sailfish	*Istiophorus platypterus*	Istiophoridae	-	-	-	0.003	0.002	100.05	-	-	-
Bermuda Chub	*Kyphosus sectatrix*	Kyphosidae	0.08	0.34	32.09	0.06	0.24	31.13	0.06	0.53	63.81
Spotfin Hogfish	*Bodianus pulchellus*	Labridae	0.009	0.004	79.84	0.04	0.04	28.60	0.03	0.02	23.76
Spanish Hogfish	*Bodianus rufus*	Labridae	0.34	0.38	17.37	0.29	0.32	9.86	0.19	0.20	16.19
Creole Wrasse	*Clepticus parrae*	Labridae	0.13	2.35	35.66	0.08	1.98	19.30	0.09	2.64	24.78
Slippery Dick	*Halichoeres bivittatus*	Labridae	0.72	5.46	9.53	0.58	2.72	7.56	0.74	5.92	11.66
Painted Wrasse	*Halichoeres caudalis*	Labridae	-	-	-	0.003	0.004	67.76	-	-	-
Yellowcheek Wrasse	*Halichoeres cyanocephalus*	Labridae	0.13	0.11	40.90	0.08	0.05	20.92	0.11	0.09	22.79
Yellowhead Wrasse	*Halichoeres garnoti*	Labridae	0.64	5.77	9.94	0.55	3.52	6.83	0.52	3.78	9.53
Clown Wrasse	*Halichoeres maculipinna*	Labridae	0.46	2.02	13.69	0.41	1.56	10.75	0.37	1.17	17.47
Rainbow Wrasse	*Halichoeres pictus*	Labridae	0.004	0.003	59.23	0.006	0.003	61.47	0.01	0.01	46.42
Blackear Wrasse	*Halichoeres poeyi*	Labridae	0.07	0.07	27.47	0.07	0.05	22.49	0.21	0.27	23.92
Puddingwife	*Halichoeres radiatus*	Labridae	0.05	0.03	38.18	0.06	0.05	37.52	0.10	0.08	28.03
Wrasse species	*Labridae* spp.	Labridae	0.01	0.03	100.24	-	-	-	0.01	0.01	62.19
Hogfish	*Lachnolaimus maximus*	Labridae	0.19	0.18	13.13	0.26	0.45	10.03	0.17	0.16	14.63
Bluehead	*Thalassoma bifasciatum*	Labridae	0.83	15.78	10.49	0.74	15.2	7.65	0.67	13.17	6.95
Rosy Razorfish	*Xyrichtys martinicensis*	Labridae	0.04	0.03	26.20	0.02	0.02	39.55	0.04	0.11	49.03

Appendix 7. (continued)

Common Name	Species	Family	2012			2013			2014		
			$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)
Pearly Razorfish	*Xyrichtys novacula*	Labridae	0.02	0.02	46.38	0.005	0.006	62.21	0.03	0.02	45.89
Green Razorfish	*Xyrichtys splendens*	Labridae	0.15	1.10	64.68	0.23	0.86	20.47	0.23	0.95	26.05
Razorfish species	*Xyrichtys* spp.	Labridae	0.005	0.004	61.25	0.009	0.01	78.17	-	-	-
Downy Blenny	*Labrisomus kalisherae*	Labrisomidae	-	-	-	0.002	0.001	100.26	-	-	-
Hairy Blenny	*Labrisomus nuchipinnis*	Labrisomidae	0.009	0.005	50.98	0.01	0.009	42.22	0.03	0.02	50.10
Rosy Blenny	*Malacoctenus macropus*	Labrisomidae	0.03	0.03	39.09	0.05	0.03	24.12	0.05	0.04	49.58
Saddled Blenny	*Malacoctenus triangulatus*	Labrisomidae	0.11	0.09	16.56	0.08	0.06	17.52	0.08	0.07	30.64
Mutton Snapper	*Lutjanus analis*	Lutjanidae	0.24	0.30	25.95	0.24	0.20	10.38	0.29	0.30	14.82
Schoolmaster	*Lutjanus apodus*	Lutjanidae	0.02	0.06	60.80	0.007	0.14	85.14	0.002	0.004	73.76
Blackfin Snapper	*Lutjanus buccanella*	Lutjanidae	-	-	-	0.001	0.0003	105.47	-	-	-
Red Snapper	*Lutjanus campechanus*	Lutjanidae	-	-	-	-	-	-	0.0002	0.0001	100.57
Cubera Snapper	*Lutjanus cyanopterus*	Lutjanidae	-	-	-	0.002	0.001	82.63	0.0002	0.0001	100.57
Gray Snapper	*Lutjanus griseus*	Lutjanidae	0.12	0.44	27.07	0.12	0.45	23.03	0.04	0.15	25.57
Dog Snapper	*Lutjanus jocu*	Lutjanidae	-	-	-	0.006	0.004	59.20	0.002	0.001	55.23
Mahogany Snapper	*Lutjanus mahogoni*	Lutjanidae	0.02	0.02	78.52	0.01	0.06	69.89	0.004	0.002	38.20
Snapper species	*Lutjanus* spp.	Lutjanidae	0.01	0.005	54.22	0.0005	0.0002	106.61	-	-	-
Lane Snapper	*Lutjanus synagris*	Lutjanidae	0.06	0.61	81.39	0.08	1.49	47.52	0.10	0.34	40.60
Yellowtail Snapper	*Ocyurus chrysurus*	Lutjanidae	0.32	1.98	30.46	0.24	0.96	35.05	0.20	0.41	17.82
Vermilion Snapper	*Rhomboplites aurorubens*	Lutjanidae	0.02	0.04	79.76	0.001	0.003	84.78	0.001	0.001	56.89
Sand Tilefish	*Malacanthus plumierii*	Malacanthidae	0.03	0.03	52.85	0.05	0.03	22.95	0.13	0.10	20.19
Tarpon	*Megalops atlanticus*	Megalopidae	0.002	0.001	100.17	0.004	0.002	99.40	0.02	0.02	72.36
Giant Manta	*Manta birostris*	Mobulidae	0.002	0.002	100.17	-	-	-	-	-	-

Appendix 7. (continued)

Common Name	Species	Family	2012			2013			2014		
			$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)
Scrawled Filefish	*Aluterus scriptus*	Monacanthidae	0.18	0.12	20.46	0.10	0.08	12.94	0.12	0.12	16.93
Filefish species	*Aluterus* spp.	Monacanthidae	0.004	0.002	63.81	0.004	0.02	85.44	0.01	0.003	72.70
Whitespotted Filefish	*Cantherhines macrocerus*	Monacanthidae	0.03	0.02	68.35	0.03	0.02	22.15	0.02	0.01	50.04
Orangespotted Filefish	*Cantherhines pullus*	Monacanthidae	0.12	0.07	20.27	0.11	0.07	13.65	0.12	0.09	18.44
Fringed Filefish	*Monacanthus ciliatus*	Monacanthidae	-	-	-	-	-	-	0.01	0.003	86.95
Slender Filefish	*Monacanthus tuckeri*	Monacanthidae	0.06	0.04	41.84	0.06	0.06	20.73	0.04	0.02	32.92
Planehead Filefish	*Stephanolepis hispidus*	Monacanthidae	0.06	0.04	21.87	0.05	0.03	19.19	0.06	0.04	39.65
Unicorn Filefish	*Aluterus monoceros*	Monacanthidae	-	-	-	0.01	0.03	55.10	0.01	0.01	53.50
Orange Filefish	*Aluterus schoepfii*	Monacanthidae	0.01	0.02	99.27	0.02	0.02	47.95	0.01	0.01	38.86
Yellow Goatfish	*Mulloidichthys martinicus*	Mullidae	0.01	0.03	82.27	0.001	0.002	74.15	0.001	0.001	98.76
Spotted Goatfish	*Pseudupeneus maculatus*	Mullidae	0.42	0.70	12.87	0.52	1.34	8.36	0.27	0.45	19.67
Dwarf Goatfish	*Upeneus parvus*	Mullidae	-	-	-	-	-	-	0.0003	0.001	101.68
Chestnut Moray	*Enchelycore carychroa*	Muraenidae	-	-	-	-	-	-	0.004	0.002	100.06
Viper Moray	*Enchelycore nigricans*	Muraenidae	-	-	-	0.001	0.001	71.42	-	-	-
Green Moray	*Gymnothorax funebris*	Muraenidae	0.009	0.004	54.93	0.01	0.009	32.69	0.01	0.01	44.63
Goldentail Moray	*Gymnothorax miliaris*	Muraenidae	0.004	0.002	51.30	0.009	0.006	37.55	0.01	0.01	45.62
Spotted Moray	*Gymnothorax moringa*	Muraenidae	0.04	0.02	55.59	0.04	0.02	20.67	0.03	0.02	29.69
Purplemouth Moray	*Gymnothorax vicinus*	Muraenidae	0.007	0.003	45.62	0.006	0.003	53.37	0.01	0.005	67.53
Spotted Eagle Ray	*Aetobatus narinari*	Myliobatidae	0.01	0.005	66.15	0.003	0.002	73.72	0.002	0.002	73.27
Lesser Electric Ray	*Narcine bancroftii*	Narcinidae	0.002	0.001	100.17	-	-	-	0.0003	0.0002	75.90
Shortnose Batfish	*Ogcocephalus nastus*	Ogcocephalidae	-	-	-	-	-	-	0.004	0.002	100.06
Batfish species	*Ogcocephalus* spp.	Ogcocephalidae	-	-	-	0.001	0.0004	102.25	-	-	-

Appendix 7. (continued)

Common Name	Species	Family	2012			2013			2014		
			$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)
Sharptail Eel	*Myrichthys breviceps*	Ophichthidae	0.002	0.001	71.87	0.005	0.003	69.10	0.01	0.01	57.22
Yellowhead Jawfish	*Opistognathus aurifrons*	Opistignathidae	0.14	0.28	33.66	0.09	0.15	17.07	0.17	0.29	23.24
Jawfish species	*Opistognathus* spp.	Opistognathidae	0.009	0.007	52.62	-	-	-	0.001	0.001	98.00
Dusky Jawfish	*Opistognathus whitehursti*	Opistognathidae	-	-	-	0.002	0.001	72.73	0.001	0.0003	59.12
Scrawled Cowfish	*Acanthostracion quadricornis*	Ostraciidae	0.10	0.08	31.69	0.10	0.06	15.12	0.10	0.06	19.42
Honeycomb Cowfish	*Acanthostracion polygonius*	Ostraciidae	0.08	0.04	30.43	0.06	0.03	16.68	0.08	0.04	17.94
Spotted Trunkfish	*Lactophrys bicaudalis*	Ostraciidae	0.003	0.001	59.28	0.01	0.008	42.30	0.02	0.01	48.64
Trunkfish	*Lactophrys trigonus*	Ostraciidae	0.005	0.004	57.57	0.01	0.006	44.91	0.001	0.001	98.27
Smooth Trunkfish	*Rhinesomus triqueter*	Ostraciidae	0.12	0.07	16.64	0.10	0.07	14.27	0.08	0.05	18.90
Gulf Flounder	*Paralichthys albigutta*	Paralichthyidae	0.002	0.001	100.17	-	-	-	-	-	-
Glassy Sweeper	*Pempheris schomburgkii*	Pempheridae	0.03	2.21	98.79	0.004	0.25	90.8	0.002	0.01	74.22
Cherubfish	*Centropyge argi*	Pomacanthidae	0.05	0.05	68.51	0.09	0.19	18.58	0.06	0.07	25.86
Blue Angelfish	*Holacanthus bermudensis*	Pomacanthidae	0.21	0.23	29.16	0.17	0.17	11.62	0.13	0.11	17.01
Queen Angelfish	*Holacanthus ciliaris*	Pomacanthidae	0.16	0.15	24.84	0.18	0.16	12.24	0.14	0.11	13.73
Townsend Angelfish	*Holacanthus townsendi*	Pomacanthidae	0.01	0.009	75.51	0.02	0.01	35.61	0.03	0.02	41.92
Rock Beauty	*Holacanthus tricolor*	Pomacanthidae	0.34	0.51	16.14	0.31	0.41	6.28	0.26	0.40	8.59
Gray Angelfish	*Pomacanthus arcuatus*	Pomacanthidae	0.44	0.57	14.23	0.41	0.46	7.35	0.34	0.40	10.09
French Angelfish	*Pomacanthus paru*	Pomacanthidae	0.21	0.25	23.75	0.27	0.26	10.35	0.30	0.23	13.40
Sergeant Major	*Abudefduf saxatilis*	Pomacentridae	0.20	2.05	19.12	0.10	1.59	31.02	0.11	1.04	35.75
Blue Chromis	*Chromis cyanea*	Pomacentridae	0.17	2.12	29.48	0.18	1.75	14.28	0.13	0.82	13.08
Yellowtail Reeffish	*Chromis enchrysura*	Pomacentridae	0.14	0.53	44.84	0.19	0.81	23.70	0.16	0.40	20.30
Sunshinefish	*Chromis insolata*	Pomacentridae	0.11	0.74	32.74	0.20	1.21	13.13	0.14	1.10	23.57

Appendix 7. (continued)

Common Name	Species	Family	2012			2013			2014		
			$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)
Brown Chromis	*Chromis multilineata*	Pomacentridae	0.14	1.45	26.02	0.06	0.81	46.10	0.06	0.47	26.32
Purple Reeffish	*Chromis scotti*	Pomacentridae	0.13	1.25	45.54	0.08	0.46	22.74	0.10	0.71	21.62
Yellowtail Damselfish	*Microspathodon chrysurus*	Pomacentridae	0.02	0.04	54.79	0.02	0.03	52.87	0.005	0.003	40.75
Dusky Damselfish	*Stegastes adustus*	Pomacentridae	0.09	0.11	30.73	0.06	0.08	26.08	0.05	0.04	25.44
Longfin Damselfish	*Stegastes diencaeus*	Pomacentridae	0.03	0.07	41.58	0.01	0.01	39.64	0.01	0.01	85.36
Beaugregory	*Stegastes leucostictus*	Pomacentridae	0.23	0.43	17.87	0.13	0.18	17.25	0.24	0.43	21.76
Bicolor Damselfish	*Stegastes partitus*	Pomacentridae	0.72	18.91	11.24	0.76	19.83	5.57	0.70	14.26	7.47
Threespot Damselfish	*Stegastes planifrons*	Pomacentridae	0.04	0.05	32.15	0.03	0.02	29.70	0.02	0.02	39.09
Damselfish species	*Stegastes* spp.	Pomacentridae	0.001	0.001	73.39	0.02	0.10	52.61	0.003	0.04	92.80
Cocoa Damselfish	*Stegastes variabilis*	Pomacentridae	0.39	0.92	24.83	0.37	0.59	8.94	0.38	0.91	24.29
Glasseye Snapper	*Heteropriacanthus cruentatus*	Priacanthidae	0.03	0.24	94.40	0.007	0.005	42.91	0.01	0.01	58.77
Bigeye	*Priacanthus arenatus*	Priacanthidae	0.03	0.05	84.74	0.006	0.02	60.99	0.04	0.02	42.75
Blue Dartfish	*Ptereleotris calliura*	Ptereleotridae	0.09	0.22	25.93	0.08	0.10	19.02	0.16	0.32	21.00
Hovering Dartfish	*Ptereleotris helenae*	Ptereleotridae	0.03	0.11	36.23	0.03	0.03	36.5	0.08	0.16	30.83
Cobia	*Rachycentron canadum*	Rachycentridae	-	-	-	0.004	0.002	89.35	0.001	0.001	91.97
Atlantic Guitarfish	*Rhinobatos lentiginosus*	Rhinobatidae	0.002	0.001	84.49	0.007	0.003	69.90	-	-	-
Bluelip Parrotfish	*Cryptotomus roseus*	Scaridae	0.20	0.57	22.42	0.21	0.66	11.98	0.30	1.12	18.93
Emerald Parrotfish	*Nicholsina usta*	Scaridae	-	-	-	0.005	0.003	60.09	0.03	0.09	70.00
Midnight Parrotfish	*Scarus coelestinus*	Scaridae	0.005	0.003	62.23	0.001	0.005	93.08	0.003	0.004	55.53
Blue Parrotfish	*Scarus coeruleus*	Scaridae	0.008	0.008	57.11	0.02	0.02	27.70	0.01	0.01	27.90
Rainbow Parrotfish	*Scarus guacamaia*	Scaridae	0.06	0.07	28.19	0.02	0.04	54.17	0.01	0.02	55.08
Striped Parrotfish	*Scarus iseri*	Scaridae	0.44	3.60	9.40	0.28	1.03	14.70	0.24	1.35	25.94

Appendix 7. (continued)

Common Name	Species	Family	2012			2013			2014		
			$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)
Parrotfish species	*Scarus* spp.	Scaridae	0.03	0.09	65.27	0.03	0.02	28.13	0.02	0.02	48.80
Princess Parrotfish	*Scarus taeniopterus*	Scaridae	0.29	0.94	12.27	0.20	0.49	11.45	0.14	0.39	27.71
Queen Parrotfish	*Scarus vetula*	Scaridae	0.02	0.01	42.86	0.04	0.04	26.66	0.01	0.004	28.02
Greenblotch Parrotfish	*Sparisoma atomarium*	Scaridae	0.45	1.62	16.83	0.39	0.83	10.95	0.44	2.20	13.85
Redband Parrotfish	*Sparisoma aurofrenatum*	Scaridae	0.63	3.56	7.55	0.58	3.10	7.78	0.53	2.65	8.49
Redtail Parrotfish	*Sparisoma chrysopterum*	Scaridae	0.08	0.19	31.75	0.09	0.09	17.30	0.08	0.05	21.96
Bucktooth Parrotfish	*Sparisoma radians*	Scaridae	0.02	0.06	48.39	0.07	0.11	22.86	0.11	0.17	24.67
Yellowtail Parrotfish	*Sparisoma rubripinne*	Scaridae	0.12	0.19	23.90	0.10	0.11	21.42	0.07	0.06	25.35
Parrotfish species	*Sparisoma* spp.	Scaridae	-	-	-	0.008	0.01	82.40	0.0004	0.0003	72.05
Stoplight Parrotfish	*Sparisoma viride*	Scaridae	0.32	0.64	12.29	0.30	0.44	9.00	0.19	0.29	14.64
Jackknife Fish	*Equetus lanceolatus*	Sciaenidae	0.007	0.006	74.69	0.006	0.008	84.60	0.02	0.01	67.45
Spotted Drum	*Equetus punctatus*	Sciaenidae	0.03	0.03	33.47	0.03	0.02	28.90	0.003	0.002	43.37
Reef Croaker	*Odontoscion dentex*	Sciaenidae	0.002	0.04	100.72	0.005	0.02	76.99	0.002	0.01	69.47
High-hat	*Pareques acuminatus*	Sciaenidae	0.13	0.27	29.72	0.09	0.13	28.70	0.14	0.17	25.38
Cubbyu	*Pareques umbrosus*	Sciaenidae	0.002	0.009	80.11	0.006	0.04	28.61	0.003	0.01	34.51
Drum species	*Sciaenidae* spp.	Sciaenidae	-	-	-	0.007	0.009	66.80	0.01	0.01	100.27
Little Tunny	*Euthynnus alletteratus*	Scombridae	0.007	0.05	97.53	0.01	0.04	50.70	0.01	0.005	60.91
King Mackerel	*Scomberomorus cavalla*	Scombridae	-	-	-	-	-	-	0.01	0.01	62.46
Spanish Mackerel	*Scomberomorus maculatus*	Scombridae	0.03	0.03	36.69	0.006	0.09	70.00	0.01	0.003	90.79
Cero	*Scomberomorus regalis*	Scombridae	0.04	0.02	26.00	0.03	0.03	40.94	0.01	0.01	34.04
Lionfish	*Pterois* spp.	Scorpaenidae	0.13	0.11	30.90	0.14	0.15	17.46	0.11	0.09	19.33
Spotted Scorpionfish	*Scorpaena plumierii*	Scorpaenidae	0.09	0.05	30.8	0.05	0.03	18.35	0.07	0.04	37.19

Appendix 7. (continued)

Common Name	Species	Family	2012			2013			2014		
			$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)
Mutton Hamlet	*Alphestes afer*	Serranidae	-	-	-	0.002	0.001	100.26	0.0003	0.0002	101.68
Black Seabass	*Centropristis striata*	Serranidae	-	-	-	0.05	0.22	57.23	0.03	0.11	57.96
Graysby	*Cephalopholis cruentata*	Serranidae	0.24	0.26	26.30	0.18	0.16	8.99	0.12	0.09	11.34
Coney	*Cephalopholis fulva*	Serranidae	0.007	0.004	35.33	0.03	0.02	28.72	0.01	0.01	26.43
Sand Perch	*Diplectrum formosum*	Serranidae	0.05	0.10	33.41	0.05	0.05	31.23	0.06	0.06	54.97
Rock Hind	*Epinephelus adscensionis*	Serranidae	0.01	0.007	38.96	0.01	0.008	36.57	0.01	0.005	34.17
Red Hind	*Epinephelus guttatus*	Serranidae	0.04	0.05	84.84	0.02	0.01	28.95	0.002	0.001	77.15
Goliath Grouper	*Epinephelus itajara*	Serranidae	0.001	0.001	98.00	0.009	0.01	38.09	0.001	0.001	85.49
Red Grouper	*Epinephelus morio*	Serranidae	0.13	0.08	18.92	0.08	0.06	18.01	0.01	0.005	28.38
Blue Hamlet	*Hypoplectrus gemma*	Serranidae	0.03	0.03	27.28	0.02	0.01	30.65	0.002	0.001	55.51
Shy Hamlet	*Hypoplectrus guttavarius*	Serranidae	-	-	-	0.0004	0.0002	102.12	0.001	0.001	71.94
Indigo Hamlet	*Hypoplectrus indigo*	Serranidae	-	-	-	0.001	0.001	105.85	-	-	-
Barred Hamlet	*Hypoplectrus puella*	Serranidae	0.03	0.02	37.42	0.01	0.007	40.10	0.01	0.01	42.28
Tan Hamlet	*Hypoplectrus randallorum*	Serranidae	0.001	0.0003	103.7	-	-	-	-	-	-
Hamlet species	*Hypoplectrus* spp.	Serranidae	0.005	0.002	62.7	0.008	0.006	64.34	0.0003	0.0002	101.68
Butter Hamlet	*Hypoplectrus unicolor*	Serranidae	0.28	0.42	19.42	0.11	0.14	30.25	0.10	0.07	14.22
Wrasse Bass	*Liopropoma eukrines*	Serranidae	-	-	-	-	-	-	0.0002	0.0001	100.57
Peppermint Basslet	*Liopropoma rubre*	Serranidae	0.005	0.008	99.58	-	-	-	-	-	-
Black Grouper	*Mycteroperca bonaci*	Serranidae	0.02	0.008	45.32	0.01	0.009	35.93	0.002	0.002	64.42
Gag	*Mycteroperca microlepis*	Serranidae	0.003	0.002	58.33	0.009	0.006	38.86	0.001	0.001	42.64
Scamp	*Mycteroperca phenax*	Serranidae	0.002	0.001	54.46	0.02	0.01	29.00	0.01	0.004	37.25
Atlantic Creolefish	*Paranthias furcifer*	Serranidae	-	-	-	0.003	0.02	100.05	-	-	-

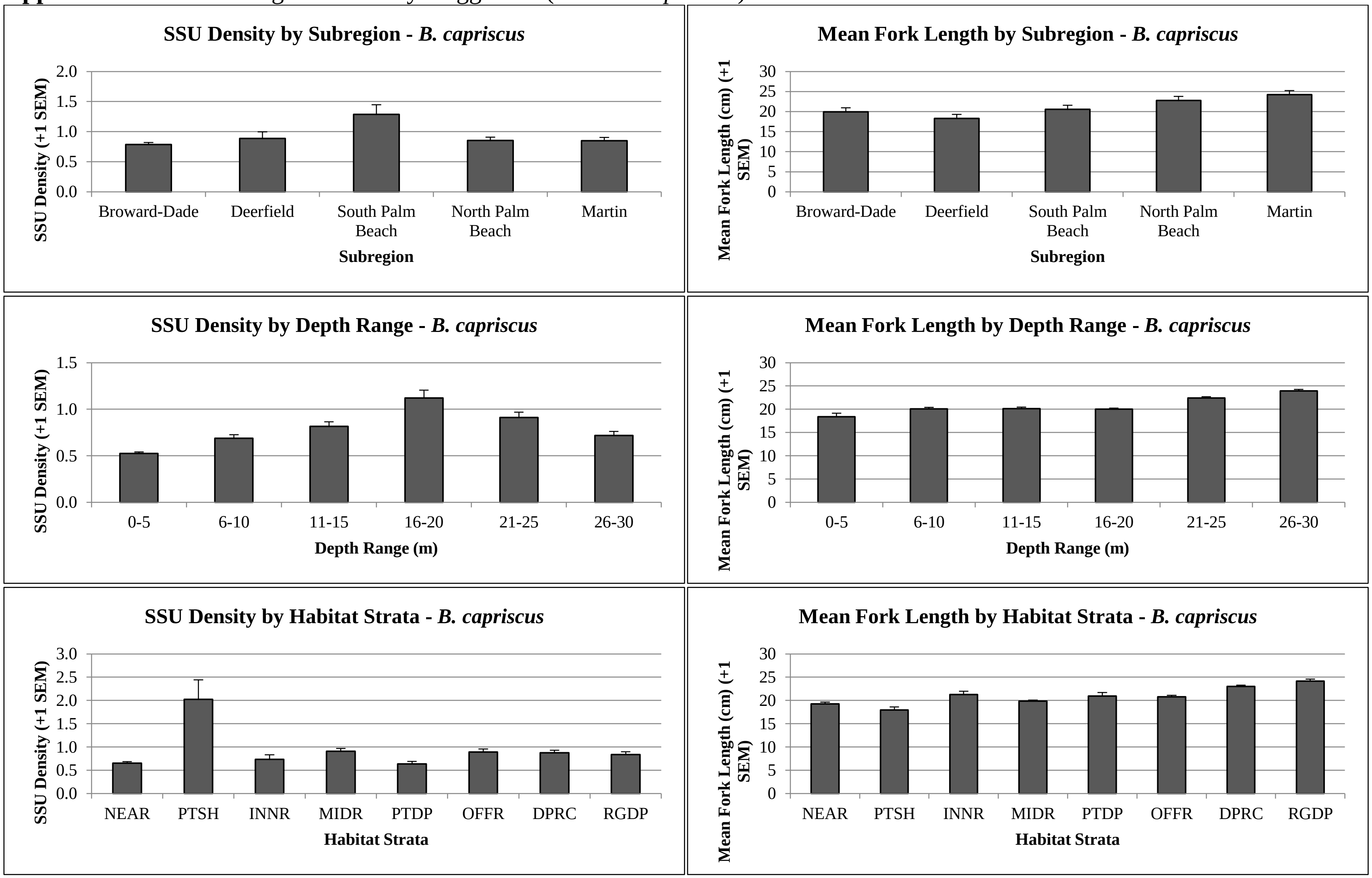
Appendix 7. (continued)

Common Name	Species	Family	2012			2013			2014		
			$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)
Freckled Soapfish	*Rypticus bistrispinus*	Serranidae	-	-	-	-	-	-	0.002	0.001	100.47
Whitespotted Soapfish	*Rypticus maculatus*	Serranidae	0.02	0.01	64.15	0.02	0.01	36.08	0.01	0.01	48.71
Greater Soapfish	*Rypticus saponaceus*	Serranidae	0.02	0.01	47.34	0.05	0.03	22.86	0.01	0.01	45.46
School Bass	*Schultzea beta*	Serranidae	-	-	-	0.01	0.69	59.66	0.01	0.02	60.76
Orangeback Bass	*Serranus annularis*	Serranidae	-	-	-	0.0003	0.0002	102.72	0.03	0.02	45.37
Lantern Bass	*Serranus baldwini*	Serranidae	0.22	0.25	28.87	0.14	0.10	13.78	0.21	0.17	16.61
Tattler	*Serranus phoebe*	Serranidae	0.02	0.01	99.90	0.005	0.003	70.13	-	-	-
Grouper-Sea Bass species	*Serranus* spp.	Serranidae	0.002	0.001	99.04	-	-	-	-	-	-
Belted Sandfish	*Serranus subligarius*	Serranidae	-	-	-	0.01	0.009	48.26	0.04	0.04	54.76
Tobaccofish	*Serranus tabacarius*	Serranidae	0.12	0.16	15.96	0.07	0.06	17.88	0.09	0.07	20.98
Harlequin Bass	*Serranus tigrinus*	Serranidae	0.38	0.53	11.77	0.26	0.28	7.34	0.20	0.22	18.66
Chalk Bass	*Serranus tortugarum*	Serranidae	0.09	0.15	24.56	0.04	0.57	73.30	0.07	0.15	29.95
Sheepshead	*Archosargus probatocephalus*	Sparidae	0.001	0.0003	96.51	0.04	0.05	30.99	0.04	0.09	78.07
Western Atlantic Seabream	*Archosargus rhomboidalis*	Sparidae	-	-	-	0.001	0.002	100.57	-	-	-
Jolthead Porgy	*Calamus bajonado*	Sparidae	0.07	0.05	51.02	0.02	0.01	48.00	0.01	0.01	50.91
Saucereye Porgy	*Calamus calamus*	Sparidae	0.15	0.19	31.34	0.12	0.11	16.08	0.24	0.36	16.79
Sheepshead Porgy	*Calamus penna*	Sparidae	0.11	0.11	45.07	0.07	0.09	30.98	0.07	0.12	38.47
Littlehead Porgy	*Calamus proridens*	Sparidae	0.18	0.24	25.82	0.08	0.08	29.99	0.06	0.04	30.94
Porgy species	*Calamus* spp.	Sparidae	0.06	0.06	58.28	0.07	0.11	28.39	0.10	0.11	29.68
Whitebone Porgy	*Calamus leucosteus*	Sparidae	-	-	-	0.03	0.06	57.67	0.02	0.01	54.21
Knobbed Porgy	*Calamus nodosus*	Sparidae	0.003	0.002	73.87	0.01	0.02	78.81	0.04	0.07	53.44
Silver Porgy	*Diplodus argenteus*	Sparidae	0.02	0.03	40.35	0.02	0.04	59.50	0.01	0.01	61.18

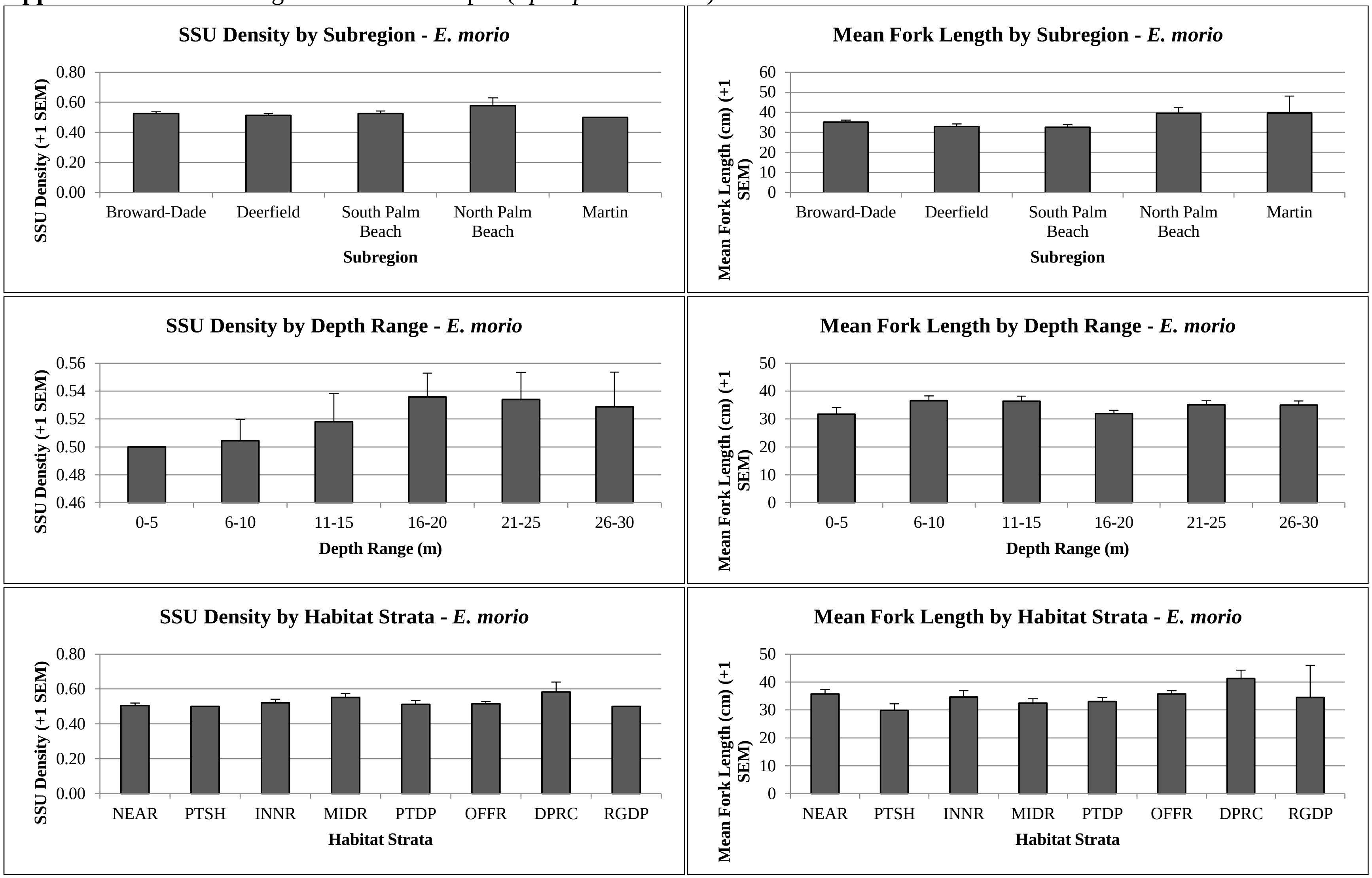
Appendix 7. (continued)

Common Name	Species	Family	2012			2013			2014		
			$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)	$\bar{P}$	$\bar{D}$	CV($\bar{D}$)
Spottail Seabream	*Diplodus holbrookii*	Sparidae	0.04	0.39	44.20	0.02	0.08	56.29	0.05	0.11	47.62
Pinfish	*Lagodon rhomboides*	Sparidae	-	-	-	-	-	-	0.0005	0.003	71.74
Great Barracuda	*Sphyraena barracuda*	Sphyraenidae	0.02	0.01	52.79	0.01	0.02	49.23	0.01	0.02	38.36
Southern Sennet	*Sphyraena picudilla*	Sphyraenidae	-	-	-	0.001	0.02	102.25	-	-	-
Scalloped Hammerhead	*Sphyrna lewini*	Sphyrnidae	0.02	0.02	99.90	-	-	-	-	-	-
Bonnethead	*Sphyrna tiburo*	Sphyrnidae	-	-	-	0.002	0.001	100.26	-	-	-
Pipefish species	*Syngnathus* spp.	Syngnathidae	-	-	-	0.001	0.0005	97.67	0.01	0.004	99.76
Inshore Lizardfish	*Synodus foetens*	Synodontidae	0.02	0.007	38.92	0.004	0.002	63.37	0.004	0.002	41.70
Sand Diver	*Synodus intermedius*	Synodontidae	0.01	0.008	38.82	0.01	0.008	48.62	0.03	0.04	73.38
Diamond Lizardfish	*Synodus synodus*	Synodontidae	-	-	-	-	-	-	0.0003	0.0003	92.29
Sharpnose Puffer	*Canthigaster rostrata*	Tetraodontidae	0.81	2.84	5.83	0.77	2.07	5.80	0.72	1.83	8.72
Southern Puffer	*Sphoeroides nephelus*	Tetraodontidae	-	-	-	0.0005	0.0002	100.69	-	-	-
Bandtail Puffer	*Sphoeroides spengleri*	Tetraodontidae	0.13	0.10	28.10	0.12	0.09	13.85	0.16	0.13	19.64
Checkered Puffer	*Sphoeroides testudineus*	Tetraodontidae	0.02	0.01	88.87	0.01	0.007	60.99	0.0001	0.0001	102.44
Bandtail Searobin	*Prionotus ophryas*	Triglidae	-	-	-	0.0005	0.0002	106.61	0.0002	0.0001	100.42
Blackwing Searobin	*Prionotus rubio*	Triglidae	-	-	-	0.003	0.001	71.92	-	-	-
Unknown species	*Unknown* spp.	unknown	0.003	0.05	99.65	0.007	0.34	99.69	-	-	-
Yellow Stingray	*Urobatis jamaicensis*	Urotrygonidae	0.07	0.05	23.30	0.06	0.03	20.36	0.06	0.03	28.22

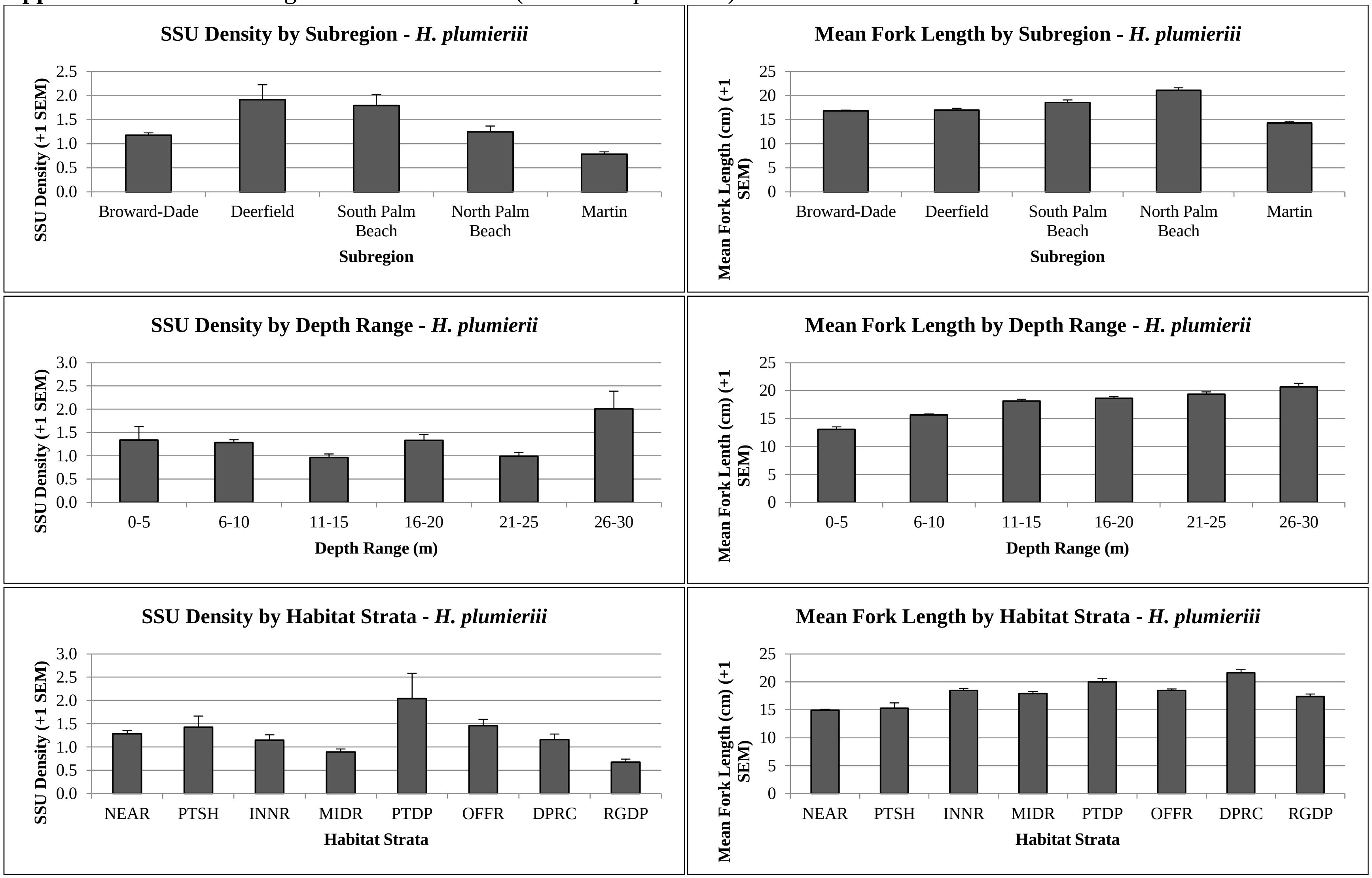
Appendix 8. Additional figures for Gray Triggerfish (*Balistes capriscus*).



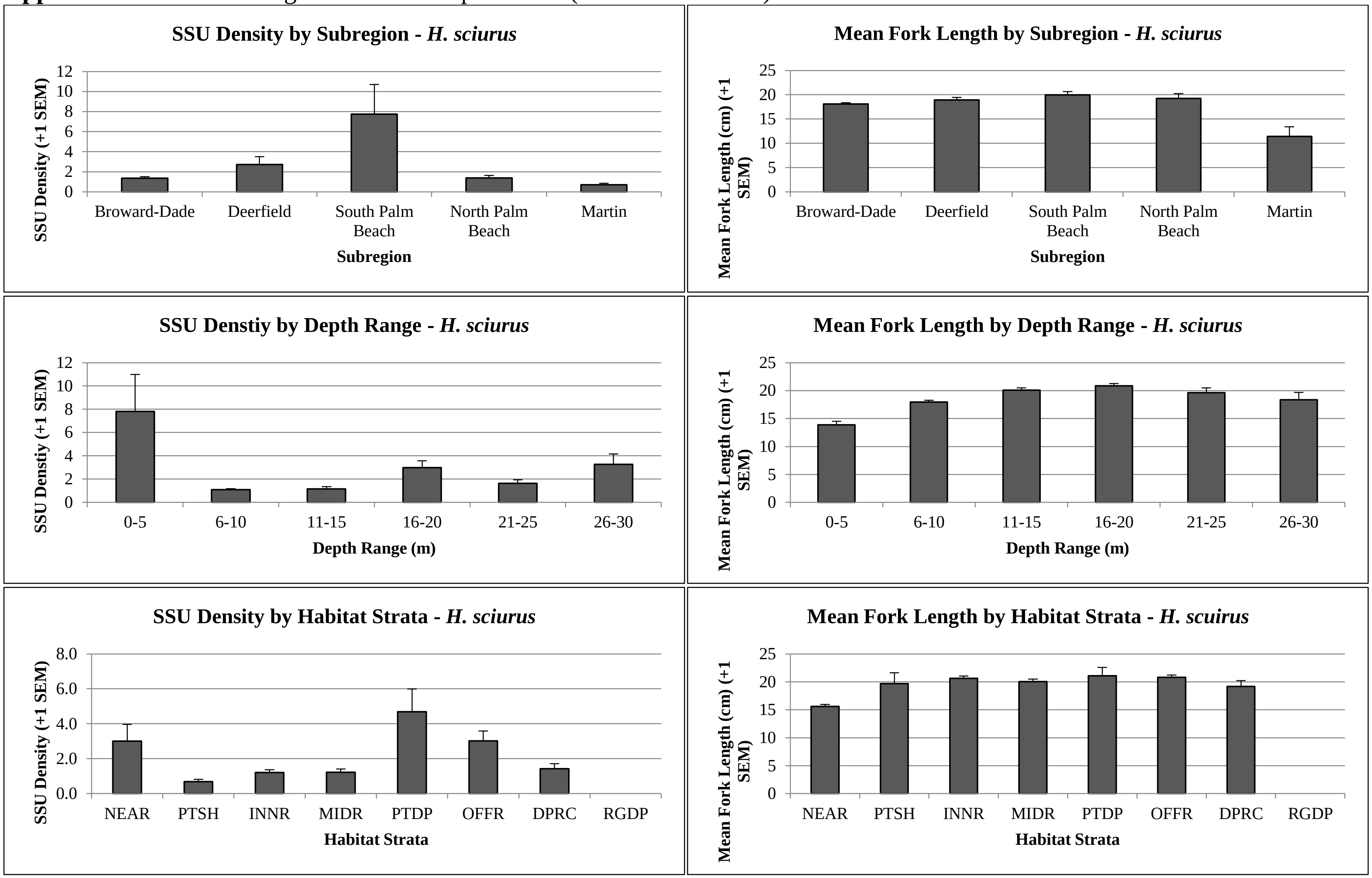
Appendix 9. Additional figures for Red Grouper (*Epinephelus morio*).



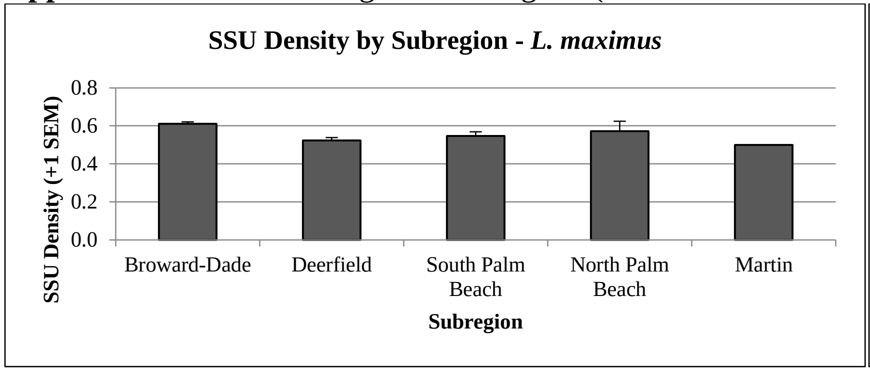
Appendix 10. Additional figures for White Grunt (*Haemulon plumierii*).

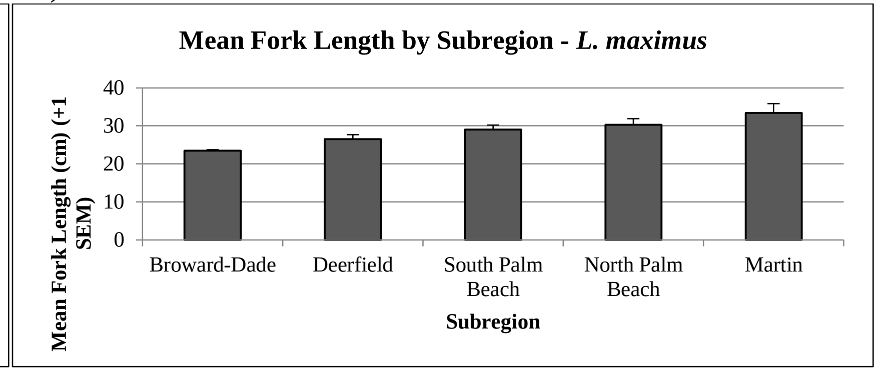


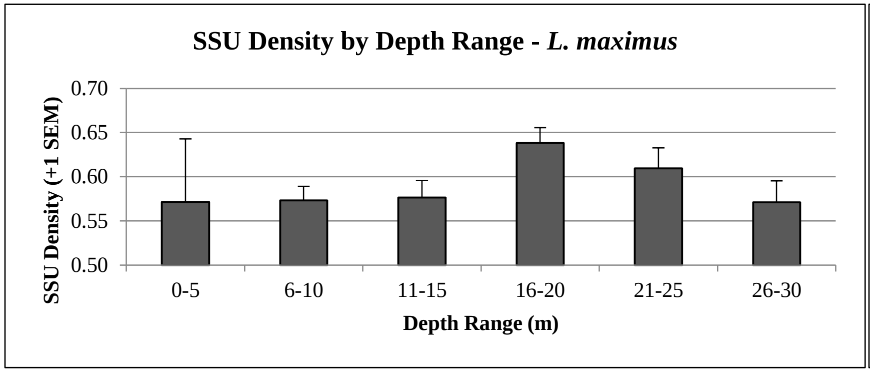
Appendix 11. Additional figures for Bluestriped Grunt (*Haemulon sciurus*).

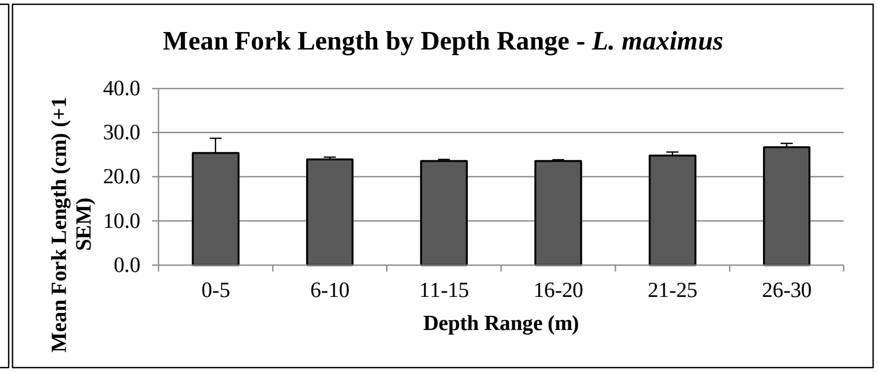


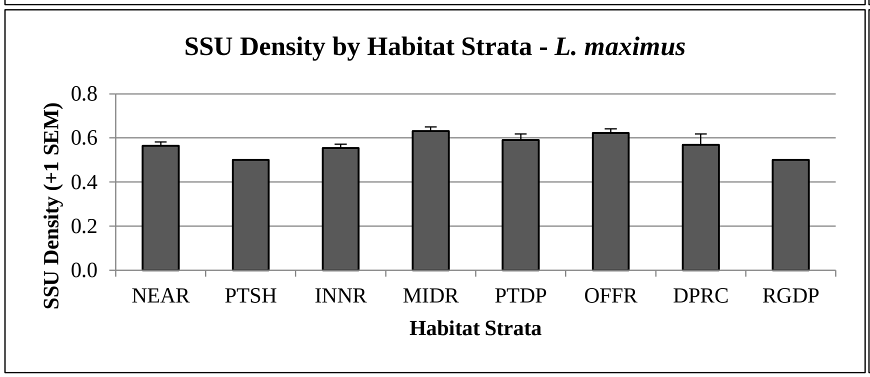
Appendix 12. Additional figures for Hogfish (*Lachnolaimus maximus*).

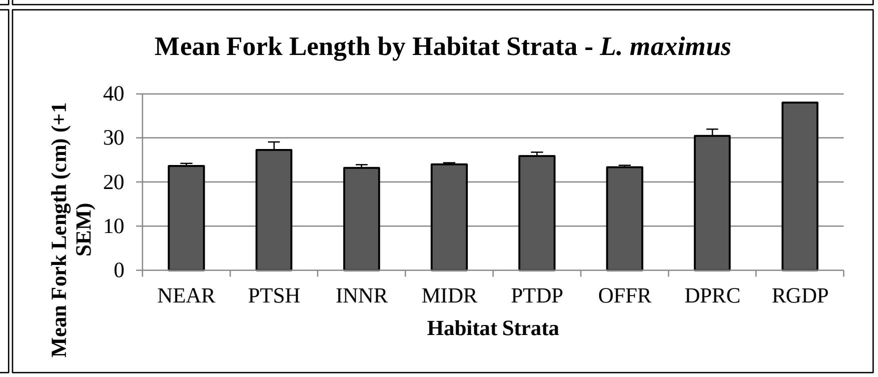




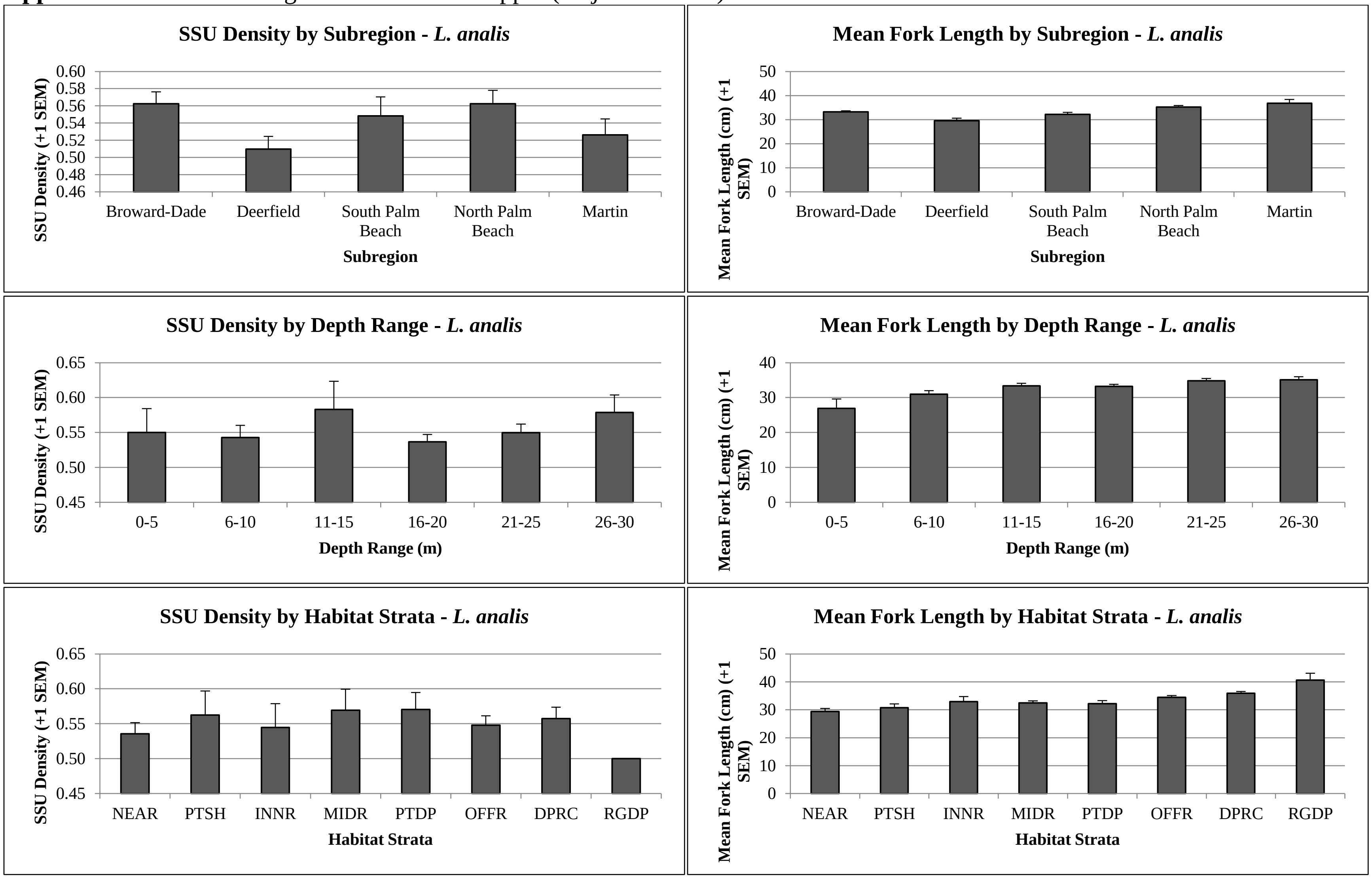




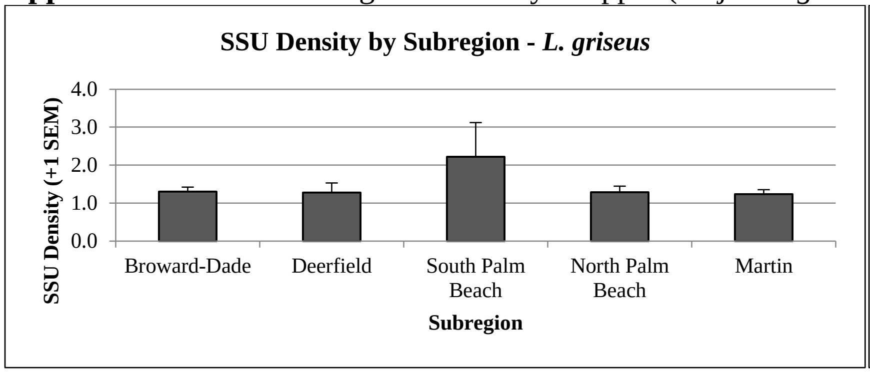


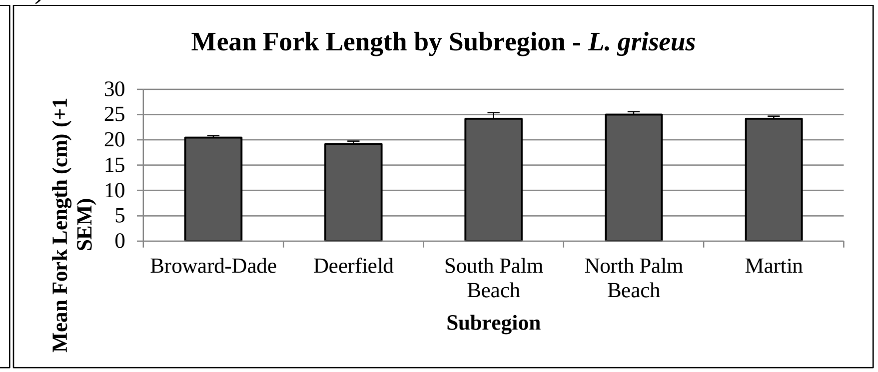


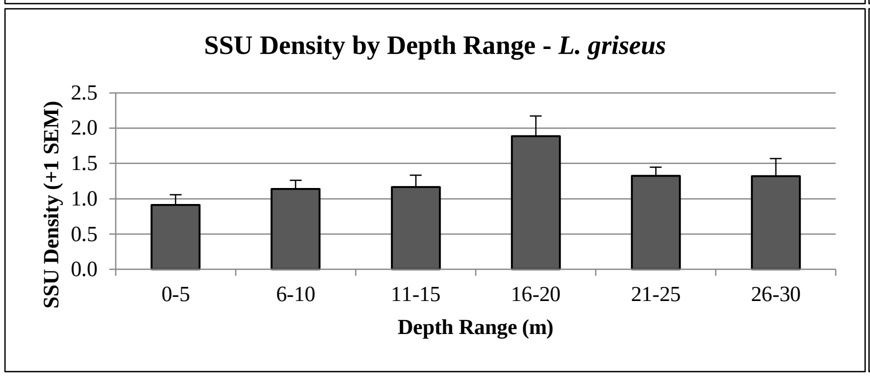
Appendix 13. Additional figures for Mutton Snapper (*Lutjanus analis*).

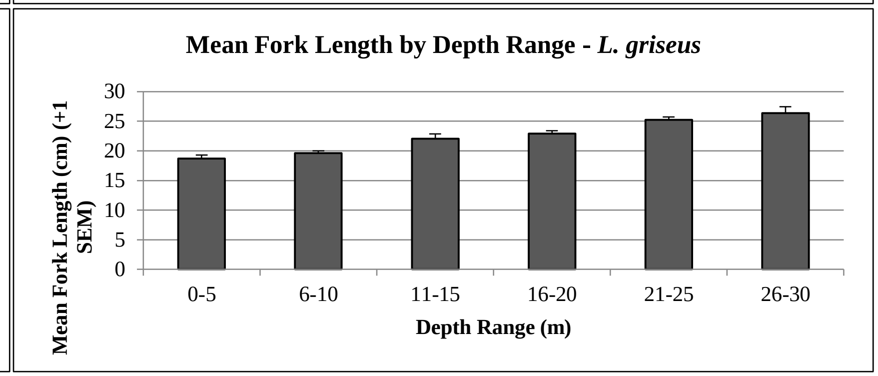


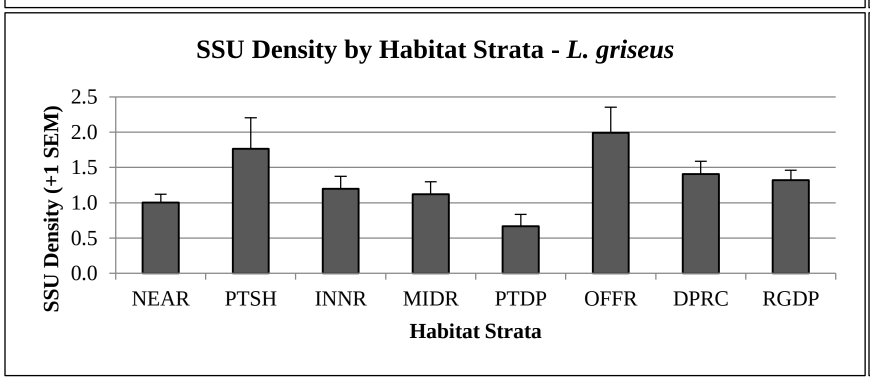
Appendix 14. Additional figures for Gray Snapper (*Lutjanus griseus*).

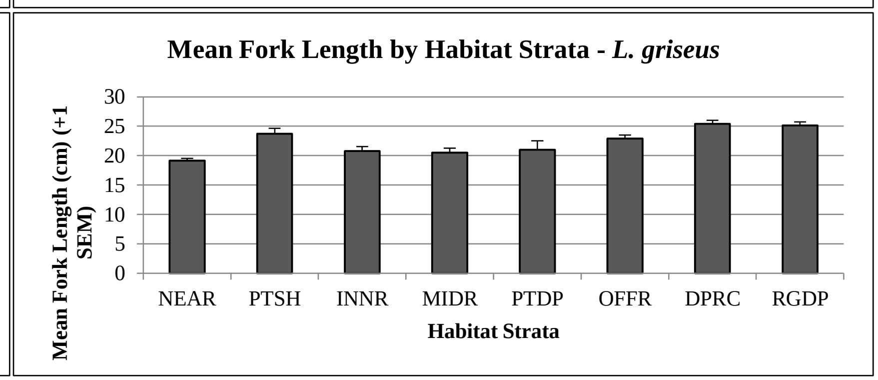












Appendix 15. Additional figures for Yellowtail Snapper (*Ocyururs chrysurus*).